

The Blast Furnace and Steel Plant

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The Blast Furnace *and* Steel Plant

Vol. XIV

PITTSBURGH, PA., DECEMBER, 1926

No. 12

Bituminous Coal Conference

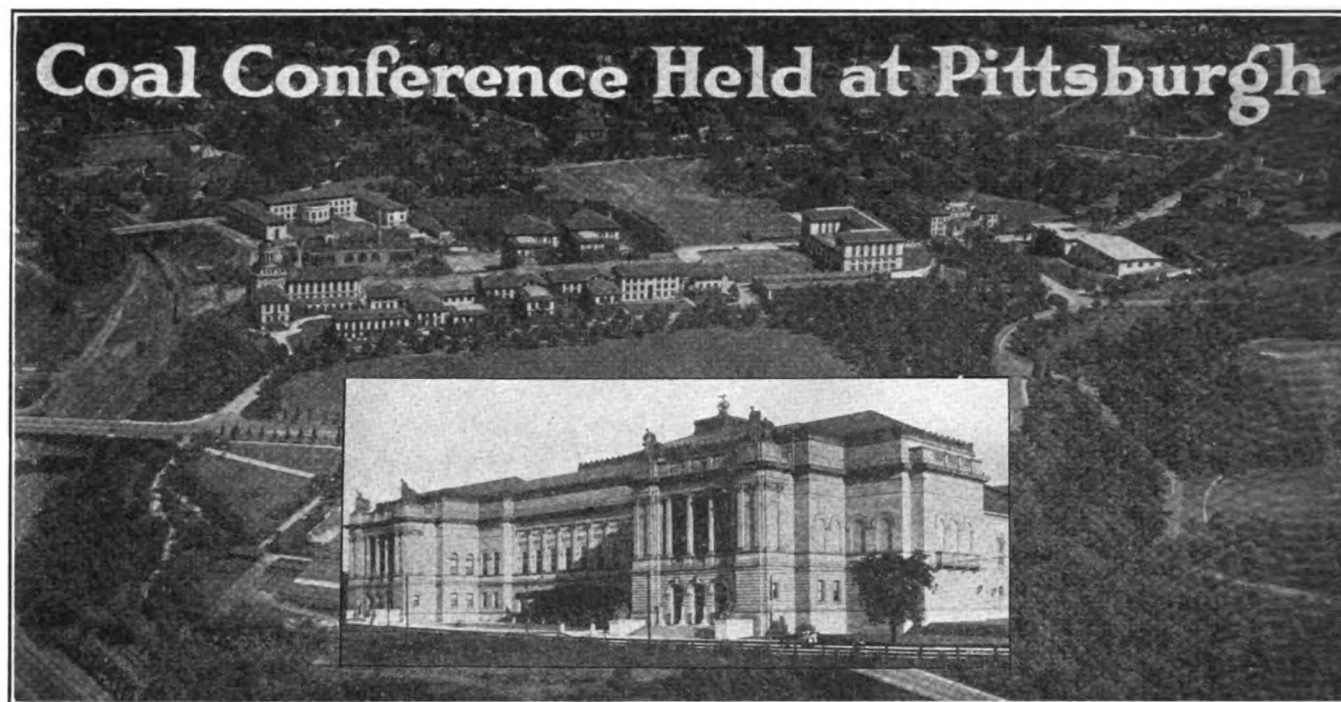
THE International Conference on Bituminous Coal, recently held at Pittsburgh under the auspices of the Carnegie Institute of Technology, was the most successful gathering of its kind ever assembled and met with far greater approval and enthusiasm than had been anticipated by its sponsors. Dr. Thomas Baker, president of the above school and under whose direct supervision the conference was held, is to be heartily congratulated on the excellent manner in which it was arranged for and conducted.

The program was the most complete ever presented on the technology of fuel, and covered almost every phase of the use and treatment of coal as well as the production of fuels and by-products synthesized from coal. Such distinguished scientists from abroad as Bergius and Fischer described their processes for the production of liquid fuels, while Lander, Patart and others dealt with research on fuel utilization and allied subjects.

Many American engineers and men of science contributed to the wealth of material presented at the conference. However, American engineers are concerned primarily with the commercial application of newly developed processes, leaving pure research to be carried out by scientists of other countries.

In his opening address, Dr. Baker said: "The United States would do well to emulate other countries in the establishment of great foundations for the study of coal. I conceive the encouragement of research to be a duty, not only because it may promote knowledge and increase wealth, but for national, I might say patriotic reasons, we must have great laboratories directed by men of high attainments. If the United States must be dependent upon foreign scholars for the development of processes which are essential in modern industry, we shall be at an incalculable disadvantage as a nation.

"The word 'research' is beginning to have a familiar sound in the ears of business men, but much remains to be done before its true meaning is realized and before we have an adequate number of gifted men to direct and do the work in the great laboratories which will be built, let us hope, in the near future. We are proud of our American scholars and engineers, and while we do not envy Europe her men of the calibre of Lander, Patart, Fischer and Bergius, we wish for our research institutions a greater number of such original minds."



Fuel Technology Discussed by Scientists

Valuable Papers Presented on the Production, Treatment and Use
of Fuels—Many Eminent Foreign Scientists Attend
—Conference May Become Annual Event

IT is difficult to talk about the International Coal Conference held in Pittsburgh, November 15-19, without using superlatives generously and superlatives are usually meaningless. However, we do not hesitate to say that the Coal Conference, held under the auspices of the Carnegie Institute of Technology and under the direct supervision of Dr. Thomas S. Baker, president of the above school, was the greatest and best attended meeting or conference of its kind ever attempted.

The conference was, as its name implies, truly international. Not only were the speakers of international reputation and from different countries, but many different countries sent delegates to attend the conference. The best measure of the success of any meeting is not only the numerical attendance, but the interest shown in the different meetings. The registration totaled approximately 1,700 and we were particularly impressed at the excellent and constant attendance at all of the meetings. Most of the meeting rooms were crowded beyond capacity, but, even so, there were very few who left before an individual meeting or session was concluded. The groups which remained to discuss subjects and papers presented at the conclusion of individual meetings or sessions was indeed inspiring.

Many new and important uses of bituminous coal were described and discussed thoroughly. It is to be expected that some of the processes described will be exploited in this and other countries and that the coal conference will prove of inestimable value in attracting to these processes.

Dr. Thomas Baker is to be heartily congratulated on the excellent manner in which the coal conference

was arranged for and conducted. Not only the bituminous mining industry, but the country at large is deeply indebted to those responsible for the International Coal Conference for it undoubtedly will be of benefit to all.

Dr. Baker's Address.

The conference was opened by Dr. Thomas S. Baker, president of the Carnegie Institute of Technology with the following words:

"In opening this International Conference on Bituminous Coal I wish first to thank the distinguished gentlemen from abroad who have made the long journey to this country and to Pittsburgh in order to place before the delegates to this meeting the results of their studies and experiments. They are adding a lustre and authority to the convention which makes it an event of first rate importance in the records of science for the current year. Without their interest and co-operation the extraordinary program which you have before you would have been impossible. And speaking for the officers and faculty of the Carnegie Institute of Technology, under whose auspices this conference is held, I offer them my hearty thanks.

"We are also deeply indebted to the eminent American engineers and men of science who have kindly consented to have a share in the proceedings. It is in a real sense an international meeting—the first, as far as I know, that has dealt with the subject of coal. The International Power Congress which was held in London in the summer of 1924 covered a broader field. We may hope that by restricting the range of our papers it may be possible to achieve more definite and practical results.

"Pittsburgh is an appropriate place in which to carry on such discussions as are about to begin, and I trust that it will not be regarded as presumptuous that the C.I.T. should have offered itself as the sponsor for this enterprise. An educational institution may undertake the task that we have assumed without suspicion of bias or interest in any special process or method. Our sole object is to do a public service, a service to our community, and a service to science in inviting the greatest authorities on the treatment of soft coal to come to Pittsburgh and to our institution and submit the results of their investigations.

Conference Surpasses Expectations.

"There can be no doubt about the importance of the subject that we shall consider. The announcement of this conference has been received with far greater approval and enthusiasm than we had anticipated. In every corner of the civilized world coal is claiming, in a way unheard of before, the attention of men of all classes, from the statesman to the cloistered research worker. Power is taking on an increasing importance in our lives. Cheaper power and a wider distinction of power may affect not only commerce and industry, but the very form and character of our civilization; and coal, will remain the chief source of energy for generations to come. It is the foundation of our industrial fabric. When we hear of the startling transformations, or transmutations, of this basic material which the scientists whose names are on this program are accomplishing, we think of the alchemists and we feel that we are on the verge of far reaching changes with respect to the technique of producing power. We are but beginning the studies which will unlock the riches which have lain hitherto locked in coal.

"It will be shown at this meeting that the liquefaction of coal is an accomplished fact. Further tests may be required to secure more economical methods of producing synthetic petroleum products, but there need be no cause for alarm at the thought of the exhaustion of natural petroleum. The coal chemist is at hand, working with the engineer, and ready to meet this emergency whenever it arises.

"In less than a generation the present methods of shipping coal to be burned in its raw state under boilers hundreds of miles from the mines will appear to have been primitive and rudely unscientific. Just what form the developments of fuel technology are going to take one dare not forecast. Of one thing we are certain, and that is that the changes will be radical, and it may not be too much to hope that this present International Conference on Bituminous Coal may mark a turning point, at least in this country, in the science of the utilization of coal.

Coal Research Valuable.

"Without attempting to prophesy in detail what will be achieved at this congress, we may state that it will illustrate in a most striking manner what can be accomplished when the principles of pure science are applied to practical questions. It will show that coal research has already revealed much—far more than the average man realizes. It will suggest that there are still extensive opportunities for further study. Many of the great modern industries owe their origin and their prosperity to the discoveries made in the laboratory. The coal producer has profited but little by the investigations of the scientists. However, the presence here of this large number of men who are interested in the mining and the sale of coal, leads to

the conclusion that they too feel that they should have a share in the advantages to be secured from research. It may appear that the highly unsatisfactory condition of this industry may urge the mine owner to seek advice and assistance in a quarter to which he has in the past rarely applied and I believe he will secure aid if he joins his efforts with those of the scientist. The United States would do well to emulate other countries in the establishment of great foundations for the study of coal. I doubt whether any line of inquiry would lead to quicker, larger or more profitable results.

Research Laboratories Essential.

"I conceive the encouragement of research to be a duty, not only because it may promote knowledge and increase wealth, but for national, I might say, patriotic reasons, we must have great laboratories directed by men of high attainments. If the United States must be dependent upon foreign scholars for the development of processes which are essential in modern industry, we shall be at an incalculable disadvantage as a nation. Our much prized economic independence and our ability to sustain ourselves without foreign aid from abroad will be seriously limited.

"Farsighted men of affairs must perceive that something more than financial resources is necessary for commercial progress. Modern business demands two kinds of capital, money, and technical and scientific knowledge. A well organized and well directed staff of research men can achieve results in a business way which cannot be secured merely by great credits. The United States is now looked upon as the financial leader of the world. We shall be able to maintain this supremacy if we build up our scientific capital—if with America's wealth and the ingenuity, energy, and resourcefulness of Americans is coupled the ability to organize and carry through scientific work of a high order. The word 'research' is beginning to have a familiar sound in the ears of business men, but much remains to be done before its true meaning is realized and before we have an adequate number of gifted men to direct and do the work in the great laboratories which will be built, let us hope, in the near future. We are proud of our American scholars and engineers, and while we do not envy Europe her men of the calibre of Lander, Patart, Fischer, and Bergius we wish for our research institutions a greater number of such original minds.

Prominent Scientists Attend.

"This is a meeting of scientific men from possibly a dozen countries, who have come together for the interchange of views. We should not overlook the benefits which proceeded from such international conferences. They must serve to promote a better understanding between the nations which are represented and with a better understanding should come mutual respect and good will. Men of science are likely to be the best messengers of peace. Furthermore, the study of coal, insofar as it increases the sum total of power that is available in the world should contribute to better international relations. For increased power implies more rapid means of communication and as the distance between nations is reduced in a physical sense, the distance between their points of view should be decreased.

"So much for the international aspects of our meeting. We hope that it may have certain parochial, or local benefits. We hope that some of the ideas that

will be brought forward may be seized upon by men of our community and put to practical use. These new ideas may mean new industries for Pittsburgh, and as our city profits by the work of scholars, she may in turn strive to be famous not only as an industrial center, but also as a place where pure science is cultivated devotedly and successfully.

"We are about to hear many addresses. Some of them embody the results of years of persevering investigation. Some of them show the inspiration which comes only to true men of science. The important thing is the original idea and the established certainty of the results that are behind the paper. The chemistry of coal is such a fascinating subject that one is tempted to speculate and even to romance about its future. We must guard ourselves against too much writing and hold ourselves strictly to the conception that the new age of power can only come by patient work and by the application of proved scientific principles. The future of coal is in the hands, not of the enthusiastic worker, but the industrious and indomitable student."

Coal Supply Discussed.

The technical session opened on Monday morning with the paper of Marius R. Campbell, senior geologist of the U. S. Geological Survey, on "Our Coal Supply: Its Quantity, Quality and Distribution." Mr. Campbell traced the location of coal and the quality of it in the various states and possessions of the United States. He stated, "According to figures submitted at the Twelfth International Geological Congress in Ottawa, Canada, in 1913, the United States contains more than half—52 per cent to be exact—of the entire coal supply of the world as it was then understood."

"In the United States at present the consumer must depend entirely upon the honesty of his dealer to supply him with the kind of coal that he has found to be most economical and satisfactory. In ordinary times he is doubtless able to get nearly what he wants, provided he can pay for it, but when a strike is declared the dealer can, if he chooses, foist any kind of coal on his patron without the latter having any recourse."

He said he hoped to see the day when the content of volatile matter, fixed carbon and ash in coal will be stamped on the railroad car after a reliable analysis has been made, in much the same manner as meats are branded today by government inspectors.

Tracing the location of the various coal deposits, Mr. Campbell said, there are two areas in the west that contain a greater quantity than the east. These are the Fort Union region of Wyoming, Montana and the Dakotas; the second, is the the Green River region of Wyoming and Colorado.

British Research on Fuel Utilization.

Dr. Cecil H. Lander, Director of Fuel Research of the Department of Scientific and Industrial Research, London, was the last speaker of the morning session. In his paper on "British Research on Fuel Utilization," he surveyed the activities of the various bodies in England which are dealing with the question of pre-treatment of coal and told of the work of the fuel research division of the Department of Scientific and Industrial Research.

At the afternoon session A. C. Fieldner, Chief Chemist of the United States Bureau of Mines and superintendent of the Pittsburgh experiment station said, "We have progressed mightily in the fields of

transportation, communication and lighting, but in the field of heating we lag behind. We are still heating our homes by the methods of a century ago, pointing out that while the apparatus may have been improved, the methods have not.

"We must not waste our reserves of coal, however, inexhaustible they may seem, in view of the new demands that will be made upon them," Mr. Fieldner warned.

"Fuel is essential to our modern industrial civilization, a continuation of our present scale of activity cannot be conceived after the mineral resources of the earth become exhausted. Therefore, in the interests of posterity, we should husband the bountiful, but definitely limited fuel reserves. Prodigious waste of this irreplaceable sources must not be countenanced. On the other hand, research on more economical utilization and the prevention of waste should be encouraged by every possible private and public means. Such research benefits this and future generations. It is a public welfare problem of the first magnitude."

Coal Transformed into Oil.

Dr. Friedrich Bergius of Heidelberg, Germany, in his paper "The Transformation of Coal into Oil by Means of Hydrogenation," gives an answer to the problem of a failing oil supply, already keenly felt in Europe and a menacing cloud on America's economic horizon.

The discovery involves using the coal beds, which scientists say are very far from exhaustion, to replace the petroleum lakes, which one after the other are going dry. Thus the international race for oil, which alarmists have seen as a probable future cause of international conflict, would be avoided since coal is far more widely distributed than the liquid fuel.

The process was found after research that was long, intensive and of wide scope. The preliminary work, was done from 1909 until the outbreak of the World war. In the course of the early experiments Dr. Bergius found a process for making coal by reproducing the conditions under which the fuel is formed in nature.

After 10 years of research on the subject Dr. Bergius decided to attempt to form oil directly from coal by changing the makeup of the hydrocarbons which are the chief ingredient of coal. This was done by adding hydrogen to the molecules of certain hydrocarbons in the coal.

The process offers many economies in production. It does not require pure hydrogen and it is possible to use the hydrogen which is produced along with the oil in the retort. The gas is regenerated by treating the vapors of the retort with steam. Very little or no coke is formed.

Another economy feature lies in the fact that lignite can be used and, in fact, gives a better yield than any other grade of coal. Anthracite can not be used since it can not be made to combine with hydrogen.

Organic Products from Coal.

General Georges Patart, Consulting Engineer of Paris, a leader in the field of catalysis, in his paper, "The Industrial Transformation of Bituminous Coal Into Organic Technical Products," told of achievements in wresting valuable by-products from coal and made the prediction that France will be able to supply herself with gasoline by combining substances made through catalytic action.

Advisory Board—International Conference on Bituminous Coal



(1) A. W. Mellon. (2) Walter Barnum. (3) Charles M. Schwab. (4) E. M. Herr. (5) Dr. Thomas S. Baker, Chairman. (6) Otto Kahn. (7) Dr. F. B. Jewett. (8) John Hays Hammond. (9) Sumner B. Ely, Secretary.

"Methyl Alcohol as a Motor Fuel," by Paul Dumanois, Chief Engineer of the Air Service of France, was a report which was concerned chiefly with the use in automobile and aeroplane engines of the fuel produced by General Patart's process. He declared that it had been used with as good effect as natural gasoline.

R. Lessing, London Consulting Engineer, brought out in his paper entitled, "Coal and Its Mineral Matter," that in order to save transportation costs and burn fuel more efficiently the world must learn how to prepare coal for the market so that the ashes are eliminated at the starting point. He pointed out that the ashes which are carried with coal in transport are so much dead weight.

Dr. Lessing said the problem of removing the ash and preventing the waste in time and labor which its transport along with the fuel content of the coal involves must be solved. To carry ashes to her furnaces and dispose of them after the coal is burned costs Great Britain about \$80,000,000 a year, he estimated.

New Uses for Pulverized Coal.

"Some New Uses for Pulverized Coal," was the title of a paper by Walter E. Trent, president, The Trent Process Company, New York. He told the conference that the world is on the threshold of a "New Age of Coal," in which the fuel will be used directly for motor operation and employed in new and other efficient methods for the creation of mechanical energy.

Powdering of coal and removal of its ash content, he said, offers possibilities for use of the piles of culm and silt which clutter the anthracite region, for low-grade anthracite and lignite can all be converted into a super-fuel of great value by proper treatment. He also stated that pulverized coal, cleaned of its ash content, can be used directly as a motor fuel in such internal combustion engines as the Diesel and Otto types. It provides a fuel of the "no-knock" type.

Men are learning to reconstruct coal as a fuel, Mr. Trent continued, rather than to use it in its raw state with the attendant waste and lack of efficiency. It is now possible to remove the ash before burning, to concentrate the fuel value and make a carbon fuel of high heat value that does not smoke.

Carbonized coal dust is a perfect fuel for central station power plants and furnaces and all steam-raising plants. Carbonized coal powder is convertible into lumps of all desired shapes and sizes which burn smokelessly, leaving no clinker and having all the characteristics of the very best anthracite coals. These reconstructed fuels will make American cities smokeless."

Powdered Coal for Power Purposes.

Henry Kreisinger of The International Combustion Engineering Corporation, New York, continued the discussion of powdered coal in its application to power plants under the title "Powdered Coal for Power Purposes." Another who continued the discussion of power generation was George A. Orrok, Consulting Engineer of the New York Edison Company, his subject was "Mouth of Mine Power Stations." The next paper was "The Relation of Thermal Storage in Boiler and Furnace to Fuel Application," by F. P. Coffin, Research Laboratory, General Electric Company, Schenectady.

Jean Bing, director, Technical Service, Coal Tar Producers and Distillers Association, Paris, France, told of various special treatments in obtaining the chemical by-products of coal, particularly in relation to the gas industry. His subject was "Bituminous Coal as a Source of Chemical Products."

Instantaneous Carbonization of Coal.

Alfred H. White, Professor of Chemical Engineering, University of Michigan, read a paper entitled "The Instantaneous Carbonization of Crushed Coal" which described experiments in rapid carbonization of coal to yield a better quality of coke and gas.

The coal crushed to pass a 20-mesh sieve is allowed to drop freely through a vertical retort heated to a rather low red heat, it carbonizes to a very considerable degree in the fraction of a second required for it to fall six feet or even a shorter distance. The coke thus produced is composed of individual particles with a porous, bubble-like structure. The amount of volatile matter may be controlled by the size of the coal and the length and temperature of the retort. It pulverizes readily and seems well adapted to use as powdered fuel. With some high volatile coals the removal of a portion of the volatile matter yields a semi-coke which gives a superior coke on destructive distillation in masses by the usual methods. The gas evolved as the coal falls through the retort does not have to filter through hot coke and so is of uniform quality.

S. R. Church, Consulting Engineer, New York, gave a brief outline of the scope of the tar products industry in the United States; comparing the principal uses for tar products in the United States and Europe. Other points taken up by him were: The trend of competition with petroleum products, economics of the tar burning by steel companies, creosote oil for wood preservation, and new uses for tar products.

Coal Tar Disposal.

John Morris Weiss, Weiss & Downs, Chemical Engineers, New York, delivered a report on "Coal Tar Disposal." The subject was treated along commercial rather than theoretical lines. He considered the magnitude of the by-product tar production in the United States, its value in relation to domestic gas and steel, and the present usual channels through which it is disposed or marketed. He took up the problems of the tar producer in attempting to determine whether it is more advantageous to sell his tar production or install a distilling plant and operate it for the production of certain primary products.

He reviewed two technical developments which have taken place in the United States in the last decade, first, in methods of distilling tar to obtain greater oil yields and lesser distilling costs, and second, in the production commercially of pitch coke. The first development has resulted in an increase of tar values of about 2 cents per gallon and the latter has removed the "burden of pitch" from the industry by affording an elastic outlet for surplus pitch which in the past has been a very serious drawback in handling increased tonnages of tar.

The probable outlets for the low temperature tars of the future was discussed and the rather extravagant claims as to tar value made by some promoters of low temperature carbonization processes were questioned. Weiss believes that any estimates of tar value above the value of liquid fuel are unsound under present conditions if large tonnages are produced.

Foreign Speakers at the Conference on Bituminous Coal



(1) Dr. Friedrich Bergius, Germany. (2) Professor Franz Fischer, Germany. (3) Geoffrey M. Gill, England. (4) C. H. Lander, England. (5) General Georges Patart, France. (6) Harold Nielsen, England. (7) Dr. R. Lessing, England. (8) Jean Bing, France.

Recovery of Phenols from Tar.

Two papers of a highly technical nature followed: "The Recovery of Phenols from Steel Plant Fuel Tars," by Robert M. Crawford, Chemical Engineer, Pittsburgh, and "The Formation of Naphthalene During High Temperature Carbonization," by Dr. Yoshikiyo Oshima, Director of the Imperial Fuel Research Institute and Professor of Applied Chemistry, Tokio Imperial University, Japan.

At the evening session on Tuesday Walter Barnum, president of the National Coal Association spoke on "What Bituminous Coal is Doing for Itself and for the Nation" and Dr. Edwin E. Slosson, director, Science Service, Washington, D. C., spoke on "The Coming of the New Coal Age."

Absolute dependence of industry on the bituminous coal supply was emphasized by Mr. Barnum, who declared that soft coal was and would continue to be the principal industrial and domestic fuel supply of the nation. He pointed to the way in which the bituminous industry had met the demands upon it and declared that the only interruptions it ever experienced had been from transportation deficiencies.

The only disruptive causes within the industry, he said, are labor causes. The danger from this source has decreased by the reduction of union operation and the increase of output under non-union conditions.

"An industry which has been functioning for more than a century and a half and during its entire life has had only four marked interruptions of supply on account of labor difficulties can certainly stand comparison with the other major industries of the country," he said.

The sudden rise in prices of coal experienced twice in this country since the war, once within the last month, were due entirely to causes outside the nation. The reason, he declared, was export demand and was beyond the control of American operators and even beyond the control of the government, despite the many demands for intervention.

America has fared well in the improvements of mining conditions and increased her output without an increased labor supply. He pointed out statistics showing that this country mines about twice as much coal per man employed in the industry as Great Britain.

Dr. Slosson said, "In the old coal age, which has lasted now some 600 years, we knew nothing better to do with coal than to burn it. But in the new coal age now opening we have found that coal can be put to better purposes than to be burnt in its crude state; that when we use it merely as a fuel we are losing compounds that may sometimes be worth more to the world than the heat obtained. We are beginning to realize the value of coal as a source of raw material for the synthetic chemist. I am of course referring to bituminous coal. Anthracite is not so useful from the chemist's standpoint."

He recalled what the conference had been told of European efforts to make oil from coal and the possibilities which the success of the attempts opened up.

"The chief stimulus to such investigations in Europe is the search for a home-made fuel," Dr. Slosson continued. "We Americans are not interested in this question now, but some day we shall be, and meantime it is interesting to watch the chemists seeing how many different things they can make out of common coal, like children playing with the Chinese tangram."

"When kerosene first came into use as a lamp illuminant it was called 'coal-oil,' for it used to be supposed that petroleum had somehow been formed from coal. Later the theory was called in question and geologists are still disputing the origin of oil. We seem likely to use it up before we know where it came from. But even if coal-oil turns out to have been an inappropriate name in the past, it may prove to be true in the future. For petroleum can be made from coal, and some day we shall all have to make it that way."

The Synthesis of Petroleum.

The Wednesday morning session of the conference was opened by Professor Franz Fischer, Director of the Institute of Coal Research, Mülheim-Ruhr, Germany, with a paper on "The Synthesis of Petroleum." Professor Fischer devoted his entire discussion to the chemistry of petroleum and its synthesis by known processes. He took up the Bergius hydrogenation-decomposition of coal and Sabatier's work on the reduction of carbon monoxide. This led up to his own work on the hydrogenation of carbon monoxide and certain catalysts to produce synthol.

Benzine or lubricating oil is "built up" through his method, and he showed samples obtained from an experimental plant. In one bottle was a clear yellow oil, the petroleum, a small quantity of lubricating oil and a more abundant quantity of solid paraffin.

In the larger bottle was an oil as clear as water and which he stated showed up well when tested as a motor fuel. Professor Fischer discussed various kinds of benzine on the market today, which are inferior to that in trade before the World war. One of the complaints against benzine is in the high-boiling parts which tend to cause so-called knocking in automotive engines.

Low boiling benzine that is synthesized by his method will overcome many of these difficulties, Professor Fischer said. In manufacturing, it would be most practical at the beginning to make the process an intermediate process in water gas plants, to take out the benzine, and to continue to use the gas then left as formerly.

The largest gas generators which are available are the blast furnaces, the waste gas of which is relatively pure, especially in regard to sulphur, and could be used for the production of benzine if hydrogen were added.

Finally we may mention that natural gas or methane of any other origin and, also, any other petroleum-like hydrocarbons can be used for benzine production according to our method, if they are first mixed with steam and then heated to such a degree that water gas is formed."

He concluded by declaring that even though the opinion has been expressed that organic chemistry had also run its course, the chemistry of carbon monoxide proves that, at least, in the field of methods, results of no small importance are still to be attained.

Developments in Carbonization of Coal.

Geoffrey M. Gill, Consulting Engineer of London, England, in a paper on "Developments in the Carbonization of Coal in Gas Works," outlined the uses and general characteristics of English gas coals, and the growth of gas consumption during the present century and the quantity of coal, coke and oil used in manufacture.

American Speakers at the Coal Conference Held at Pittsburgh



(1) A. C. Fieldner. (2) S. W. Parr. (3) E. E. Slosson. (4) W. H. Fulweiler. (5) H. A. Brassert.
(6) Scott Turner. (7) Walter E. Trent. (8) O. P. Hood.

New developments in the field of gas manufacture were discussed by W. H. Fulweiler, chemical engineer, The U. G. I. Contracting Company, Philadelphia. This trend of discussion was continued by C. J. Ramsburg, vice president, The Koppers Company, Pittsburgh.

Mr. Ramsburg stated, "Economic conditions have brought the gas industry face to face with new problems. The growth in the use of the internal combustion engine, with the resulting increased production in gasoline, will eventually make gas oil so valuable that its use in manufacturing carburetted water gas should and will be reduced to a minimum. It is probable that the solution of this problem is to be found in the production of coal gas, diluted with blue gas or producer gas to a fixed quality as a base load. To this base load must be added the peak load gas—blue gas or carburetted water gas."

"People outside the gas industry are sometimes prone to think that gas has had its day, and that electricity will take its place. There are no signs of such transformation, and in fact where electricity has been most strenuously pushed, there gas is making very satisfactory progress. Both are essential services, and will continue to be so. Both have a great future ahead of them. That is the position as the author sees it both in Europe and in the United States."

Utilization of Heat in Steel Plants.

H. A. Brassert, Consulting Engineer of Chicago, read a paper on "Utilization of Heat in Modern Steel Plants." Louis C. Jones of the Nitrogen Engineering Corporation, New York described to the Fertilizer Section of the International Coal Conference the methods by which fertilizer can be made through the use of coal at one half the cost of electrical production. Mr. Jones predicted that the new processes for making fertilizer forever will insure the world against the failure of its food supply, or any major shortage. With the strides chemistry had made, he said, we may some day be turning coal and wood directly into food.

At present 80 per cent of the world's nitrates, the principal fertilizer, it being produced, not through the application of electric power, but through the synthetic processes which involve the use of coal.

Other papers given before the Fertilizer Section were "Coal as a Source for Fertilizer," by Harry A. Curtis, Professor of Chemical Engineering, Yale University; "Economic Aspects of the Fertilizer Industry," by Chas. J. Brand, executive secretary and treasurer, The National Fertilizer Association; and "The Relation of Coal to Fertilizer," by Dr. Frederick G. Cottrell, director, Fixed Nitrogen Research Laboratory, U. S. Department of Agriculture.

Problem of Smoke Abatement.

The problem of smoke abatement and the production of smokeless fuel were discussed before the Smokeless Fuel Section of the Conference in papers read by Dr. Horace C. Porter, Consulting Chemical Engineer of Philadelphia; O. P. Hood, Chief Technologic Branch, U. S. Bureau of Mines and Osborn Monnett, Consulting Engineer of Chicago.

Dr. Porter in his paper "The Economic Aspects of the Conversion of Coal into Smokeless Fuel," saw relief from smoke in the increased use of gas and in the use of reconstructed coal as smokeless fuel. But smokeless fuel can not, at least under present conditions, be given to the public as cheaply as raw fuel and if the

smoke problem of cities is to be solved the public must pay more for its heat.

"Smokeless Fuel" is not being supplied the public simply because the public does not want smokeless cities badly enough to pay the price for such a product, Mr. Hood told the delegates.

Instances have been found where almost every fuel has been made to burn smokelessly through engineering skill, Mr. Hood said, and there is every reason to believe that it can be done anywhere. But most engineering is a compromise to meet financial and operating limitations; and the smoke nuisance will not be entirely abated until the public learns to have cleanliness and comfort enough to pay a higher price for it.

Smoke Problem of Cities.

The efforts to bring about smoke abatement with its resultant increase in cleanliness, comfort and health has not been at all satisfactory, was reported by Mr. Monnett in his paper "The Smoke Problem of Cities." Public indifference and lack of knowledge on the part of householders and small plant firemen of how to burn fuel, he said, have nullified much of the work.

In cities where raw bituminous coal must be the basis of fuel study, Mr. Monnet said, smoke abatement is achieved only by the closest supervision of methods and equipment, educational efforts and the most unrelenting vigilance in following up operations. This in effect, he concluded, imposes a tax on communities which very few of them have seen fit to pay. Thus progress has been slow and will remain so as long as the necessity of using raw fuel exists.

Dr. S. W. Parr, Professor of Applied Chemistry, University of Illinois opened the Thursday morning meeting of the conference with his paper "Fundamental Studies on Coal as Related to Carbonization Problems." He reviewed the history of the 100 years' study of the fuel problem in America, and said that progress in fuel research of the future must be based on very different factors from those of the past.

"For these fundamental studies the future holds out great encouragement by reason of the many tools which present day developments in all the physical sciences have sharpened and put in order ready for use," said Dr. Parr. "We seem suddenly to have discovered that the old methods were utterly lacking as a source of information. As a result there has already been opened up a new era in coal investigation which will certainly characterize the transition which this conference has the peculiar honor of emphasizing."

Low Temperature Distillation.

Experiments in low temperature distillation that are being conducted by the Consolidation Coal Products Company of New York at Fairmont, W. Va., were described by C. V. McIntire. The company manufactures an artificial anthracite from soft coal at low temperature, briquetting the residue and heat treating the briquettes.

He illustrated and described new apparatus for low temperature distillation and for heat treating briquettes. The possible commercial applications for this process and the benefit to the public from a low-priced artificial anthracite, were discussed by Mr. McIntire.

Harold Nielsen, Sensible Heat Distillation, Ltd., of London, made the following remarks in the introduction of his paper, "Distillation of Coal; Internal Heating; The 'L and N' Process."

"The devastating miners' strike in England has brought home to every thinking man and woman in every civilized country the vital importance of coal and fuel resources. Cheap fuel means cheap heat and power, low manufacturing costs, cheap transit and successful competition.

"Cheap fuel does not necessarily mean that the cost of digging the fuel out of the earth should be very low; if it is, all the better, but what it does mean is that a careful scientific selection of the availability of the various products obtainable is made, and that only the products, or let us say, heat units, are selected for the process or work for which they are economically most suitable."

The economic aspect of coal distillation, its cost and the correct scientific method were gone over in detail by Mr. Nielsen. He said too much has been asked of the retorting part of the processes.

"The best possible products can never be obtained in a single stage; they must be manufactured, and all the retort should be called upon to do is to effect the most economical and efficient separation from the original raw coal of the best raw products, the solid, liquid and gaseous, for their further refining and manufacture for the specific purpose for which they are wanted."

Mr. Nielsen said that through distillation and subsequent manufacture it is now possible to produce a standard powdered fuel, possessing the qualities of smokelessness, cleanliness, dryness and one that is free burning and easily ignitable. He said, oils obtained through distillations should be primary products, as it is only possible from these to build further. Lubricating oils obtainable from coals by the correct method are certainly as good as those obtained from well oils.

He said the gases obtained come in two stages of distillation—the first stage is synonymous with the oil stage, and the second is after the oils are expelled. The gas volume obtained in the second stage is generally double that obtained in the first stage.

"We have found and proved, by numerous tests, that the combustibility and reactivity of the solid residue is not in any way impaired by the removal of the very largest part of the volatile matters," Mr. Nielsen asserted.

McEwen Runge Distillation Process.

Dr. Walter Runge, of the International Combustion Engineering Corporation, of New York, described the McEwen-Runge process for the low temperature distillation of coal, in which coal is distilled and carbonized by pulverizing it and bringing it into contact with a stream of hot gases in a continuous circuit apparatus. He said, the semi-coke so produced offers many advantages for burning in steam-raising necessary.

The Greene-Lauke Process was described by F. C. Greene of the Old Ben Coal Corporation of Chicago. In this process coal is moved through a heated zone on a long screen conveyor. Its advantages according to Mr. Green, are that it produces a good quality of gas, a very good grade of tar, free of coke and the carbonized coal is dense and not easily broken, offering economies in transportation.

Emil Pixon, who invented and installed the low temperature distillation apparatus at the River Rouge plant of the Ford Motor Company, related the diffi-

culties he had encountered and told how they had been overcome, so that the process, at first thought a failure, is now becoming a commercial success. The main stumbling block in his path, he stated, had been the necessity for working on an enormous scale without the advantage of gradual research along less ambitious lines.

Other engineers who read papers were: W. A. Darrah, Continental Industrial Engineers, Inc. of Chicago, on "The Low Temperature Distillation of Coal in Rotary Retorts;" Richard B. Parker, Consulting Engineer of New York, on "The Bussey Process of Low Temperature Distillation;" Gustav Egloff, The Universal Oil Products Company of Chicago, on "The Cracking of Low Temperature Tars by the Dubbs Process;" Clarence B. Wisner, The Carbacite Company of Canton, Ohio, on "The Missing Link in Low Temperature Carbonization," and F. E. Bracker, Chemical & Physical Process Corporation of New York, on "Hydrogenation of Coal at Low Temperatures."

Mr. Egloff stated, the United States has the greatest potential source of oil supply in the world today. For the next 800 years the bituminous coal deposits of this country could supply the world's motor fuel needs, he estimated.

The United States has been estimated to have at least 1,600 trillion tons of coal underground within her borders. From that amount of coal there could be produced, 800 billion barrels of tar, which by cracking could be made to yield 240 billion barrels of high grade motor fuel.

While the nation is being warned that its oil reserves will not last longer than six years, at the present rate of consumption, science is meeting the situation through low temperature carbonization of coal. From these processes two results are achieved:

The natural oil supply, nearing depletion is replaced by a man-made product that offers better qualities as a motor fuel than the fuels obtained from the wells.

An improved, reconstructed solid fuel is obtained in which the heat value is higher, that is easier to transport, easier to handle and burns more efficiently. At the same time low grade coal, screenings and culm can be reclaimed.

Motor fuel produced from coal offers many advantages, Mr. Egloff reported. It will give over double the mileage per gallon of fuel when compared to ordinary gasoline when used in a high compression motor. It is naturally "No-knock" since it contains, when manufactured the components necessary to prevent detonation.

A. S. T. M. to Meet at French Lick Springs

The 1927 annual meeting of the American Society for Testing Materials will be held at French Lick Springs, Ind., June 20-24, and will be the first time the society has met in the Middle West. Several important considerations influenced this selection. In a recent questionnaire, 60 per cent of the members voted for some place other than Atlantic City and inasmuch as the membership is country-wide it was decided that the move should be westward. The 1927 meeting marks the twenty-fifth anniversary of the incorporation of the society and plans are being made to commemorate this.

Fuel Economy in the Steel Industry*

Possibilities of Fuel Economy in Iron and Steel Industry Discussed
—American and German Practice Compared—Output
and Labor Saving First in American Plants

By H. A. BRASSETT†

THE American iron and steel industry consumes approximately 115,000,000 tons or 20 per cent of the country's bituminous coal production. Most of this is completely gasified, either in gas producers or in coke ovens by high temperature distillation and subsequent burning of the coke in blast furnaces or cupolas; a relatively small amount is fired as coal under boilers or for other purposes. Since the consumption of bituminous coal and the production of gas therefrom have reached larger proportions in this industry than in any other, any economies in their use are of far reaching importance. At most American iron and steel plants the opportunity exists for substantial fuel savings, especially by more efficient and more complete use of surplus gases and waste heat.

Improvements in this direction not only offer a field for profitable investment but will result in the elimination of the smoke and dust nuisance which has been generally considered a necessary evil connected with iron and steel plants. A modern coke oven, blast furnace and steel plant using its fuel properly, needs no longer be a menace to pure air, health and the beauty of the surroundings in which it is located.

American and German Practice Compared.

The author was greatly impressed with the progress in this respect made by the leading iron and steel works in Germany where he had occasion to observe the results of the economical use of fuel at the leading iron and steel works. The smokeless steel plant has become the rule in Germany rather than the exception, wherever coke ovens and blast furnaces are coupled with steel works and rolling mills.

Output and Labor Saving First in American Plants.

It is generally acknowledged that, during the great development through which the American iron and steel industry has undergone since the discovery of the Mesabi Range, refinements pertaining to fuel economy, unless resulting in greater production as in the case of lower coke consumption per ton of iron at the blast furnaces, were generally considered last on the program of improvements. Sound reasons governed this policy, principally scarcity of labor combined with unlimited markets. Greater output and labor saving were the chief purposes. American blast furnaces, steel works and rolling mills took the world's lead in production, mechanical devices for labor saving, more efficient scheduling of work and application of labor. The iron and steel industry in this country compared to that of Europe excels in the rational development of balanced output integrated from raw materials to finished products; in simple layout and construction of plant, free from elaborate complications; and also in cost accounting. It also has the

advantage of better standardization of production and products.

Capital, as a general rule, was not so readily obtainable for building economical gas, steam and power plants or for the more efficient recovery of the values contained in surplus gases. Complete cleaning of blast furnace gas was not considered economical except for gas engines, and primary washed, and, in some cases even dirty gas is to this day used under stoves and boilers. Coal firing of boilers and heating furnaces in American steel plants is in many instances still carried out without regard to efficient combustion. All this holds true in England. Waste heat boilers in connection with open hearths, it is true, have been developed in America ahead of any country, but their installation was induced in part by a condition resulting from the desire for greater tonnage, necessitating a greater heat input, generally resulting in higher stack temperatures, an effect which may only be modified by the application of the most recent refinements in design and operation.

Recent Improvements in the Use of Fuel.

Higher freight rates and other factors which have developed in this country in recent years have made stricter fuel economy almost compulsory. Much progress in the economical use of fuel has lately been made as exemplified by the wide spread application of automatic combustion control resulting in better hot blast stove, boiler and heating furnace practice, the installation of much larger boilers designed for high steam pressures and superheats, and of bigger electric power generating units located in central stations; also the more complete use of coke oven gas, more general application of mechanical producers and other improvements.

Heat Economy at German Iron and Steel Plants.

Comparing the heat economy as practiced today in Germany with that prevailing in the best American plants, the greatest difference lies in the wide use of the gas engine in the former country, both for blowing and power generation, resulting in a greater percentage of surplus gas becoming available, and the complete utilization of this much greater amount of surplus blast furnace gas in their steel works and mills. They have progressed further in refinements of stove, gas engine and heating practice, as well as in the use of finely cleaned gas for all purposes. American plants on the other hand have gone further in the application of large boiler and turbine units.

There are several steel plants in Germany which, in spite of producing a wide range of products, normally consume no coal in the production of finished steel beyond that charged into the coke ovens, excepting locomotive fuel, and even this is often eliminated by the use of electric or other fireless switch engines; at other plants coal is fired only to generate power for sale or to replace coke oven gas which is

*Paper presented at the International Conference on Bituminous Coal, Pittsburgh, November 15 to 18, 1926.

†Consulting Engineer, Chicago, Ill.

sold to communities on account of its higher value. There is no fuel practice in this country comparing with this achievement, even at plants where gas engines are the prime movers.

Application of Blast Furnace and Coke Oven Gas.

From the viewpoint of ultimate economy, steel plants should be guided by the principle that blast furnace and coke oven gas should be applied primarily to all uses where a solid fuel can not be utilized, and then to where solid fuel can give equally good or even better results, especially under boilers. It is disadvantageous to fire blast furnace or coke oven gas under boilers where coke breeze and cheaper grades of coal applied in the powdered form or on efficient stokers would give excellent efficiency, and at the same time to gasify a more expensive coal for use in heating furnaces, for which purpose blast furnace and coke oven gas could be used to greater advantage. It should always be remembered that the use of blast furnace and coke oven gas for melting and heating saves the cost of gasifying an equivalent amount of high priced coal in the producer.

Steel Industry as a Producer of Gas and Power.

To gain the proper perspective in dealing with this subject, the iron and steel industry should be regarded not only as a producer of iron and steel but as a potential distributor of gas and power to affiliated and neighboring industries, public utility companies and communities.

Most of the important steel plants in Germany are tied in with coal mines and public utility companies both on gas and power delivery. The exchange of power and the sale of surplus coke oven gas is also practiced in this country. Steel plants, particularly, those not connected with blast furnaces, in some cases buy all of their power because the large public power station can sell power cheaper than it can be produced in the average steel works power plant.

This broader conception of the heat economy problem influences the selection of the various gases for specific purposes and widens the field of their commercial application and not only offers possibilities for additional profits, but is a deciding factor in assigning new values to industrial locations. This is borne out by the fact that merchant iron operations have been made profitable, where without the utilization and sale of their blast furnace and coke oven gas in one form or another, they would have suffered in competition with blast furnaces serving steel plants naturally affording such economies.

Economic Value of Blast Furnace Gas.

While the great commercial value of the surplus coke oven gas has been fully realized, blast furnace gas has not been generally appreciated. A few figures, therefore, may be of interest. The coking coal used annually in American coke ovens amounting to say 80,000,000 tons, contains a volume of coal gas released by high temperature distillation aggregating in heat value 448,000 billion Btus., which is equivalent to 17.2 million tons of coal. Of this gas, approximately 20 per cent is still being wasted because of beehive ovens. Of the balance a considerable percentage is lost through the inability to utilize the whole of the gas at all times, more particularly the week-end gas.

The total heat value in the blast furnace gas represents even a larger total than that of the coke oven

gas. For each ton of pig iron made, an average of approximately 140,000 cu. ft. of blast furnace gas is produced. At 94 Btu. per cu. ft. this represents an output of 13,160,000 Btus. per ton of iron. In an annual production of 36,000,000 tons of iron, 473,760 billion Btus. are produced, which is equivalent to 18,220.00 tons of coal. Since this tonnage is more than the total coal equivalent of the annual coke oven gas production, it suggests strongly the great economic importance of utilizing the highest possible percentage of the blast furnace gas in the most efficient manner.

Aside from a frequently observed failure to adequately value blast furnace gas in the accounting of manufacturing costs, the principal reason for not generally realizing the necessity of economizing with the use of this gas, is, of course, its low heat value which made it appear unsuitable for metallurgical purposes, and while most blast furnaces, especially those connected with steel plants, sell surplus gas to other departments, much of this is either still wasted or used with a low degree of efficiency.

The Blast Furnace as a Gas Producer.

On the other hand the mistake has been made of considering the gas producer function of the blast furnace as of such importance as to make it a reason or an excuse for high coke consumption per ton of iron. Both here and abroad there have been cases where, through the use of gas engines or of very cheap coke, the returns from surplus gas were unusually high and seemed to offset the cost of a higher coke consumption. The blast furnace is essentially designed for reducing and smelting iron ores and is not an efficient gas producer. From the results of experiments made some years ago, the author became convinced that a blast furnace is not a suitable apparatus for making gas as its main product. It is more economical to operate it in accordance with its best efficiency as a reducing and smelting unit, and to produce such excess gas as may be needed for the steel plant from coal direct, by such means and apparatus as are specifically designed to perform this duty. Slagging producers have been designed for this purpose, but the development in cheap gas production will likely be in another direction, since it will be difficult to overcome the loss of the sensible heat in the slag.

Available Surplus of Blast Furnace Gas.

The blast furnace should be operated, regardless of the output and quality of its gas, with the lowest possible coke consumption compatible with good quality of iron, by proper preparation of raw materials and the use of the highest practical blast heats. Under such conditions and with modern installations of steam and power plants, as have been built in American steel plants in recent years, 25 per cent of the amount of gas produced by the blast furnaces should be sufficient to operate the hot blast stoves. If gas blowing engines are used, approximately 18 per cent will furnish power for blowing, pumping and miscellaneous blast furnace service; if the usual steam driven turbo blowers are used, approximately 40 per cent is required for these purposes. In the former case 57 per cent of the gas is available as surplus for sale to other departments, in the latter case only 35 per cent. If gas engines are used for electric power generation, one and a half to twice the amount of power will be developed from the same amount of surplus gas.

Use of Steam Turbines vs. Gas Engines.

Nevertheless, the development in this country will very likely continue in the direction of steam turbines. Several German plants have recently installed turbine units and are considering their more extensive adoption for blowing and power generation. The steam turbine has proven that it is capable of high efficiencies if of sufficient size and backed by the proper steam plant. With the expensive skilled labor in this country, the steam turbine has the advantage of low cost of operation as well as installation and will likely be preferred in all plants except where coal costs are relatively high and where gas engines already are the prime movers. There seems to be no probability in this country of any substantial decrease in the cost of gas engines due to quantity production and standardization and the only possibility for a cheaper gas power unit is the gas turbine. In Germany the gas engine has a low initial cost, is operated with low priced labor and has been further developed than here, not only in regard to size of units, but particularly in that the waste heat both in exhaust gases and cooling water is fully utilized. Whereas a heat efficiency of 21 to 24 per cent is attained in this country on average plant performance, German gas engine stations are usually operating with efficiencies of from 26 to 30 per cent. They are quite generally equipped with scavenging and surcharging arrangements which enable an increase in the horse-power output without loss in overall thermal efficiency, because waste heat boilers are installed and the heat in the cooling water is recovered for boiler feed or other uses. Also German plants were early equipped to clean mechanically all of the blast furnace gas so that the cleaning of additional engine gas involved in the aggregate but a small extra expense.

High Thermal Efficiencies of Large Power Plants.

Recent improvements in power plant design and generating methods as embodied in the large American power stations of public utility companies must lead to the conclusion that the iron and steel industry of this country is right in attacking its power problem on the basis that the steam turbine will in the long run prove to be the most suitable prime mover. Modern power stations containing the largest units (50,000 to 77,000 kw.) and operating with steam pressures of from 500 to 1250 pounds per square inch and 250 deg. to 300 deg. superheat, can generate a kw. hour with approximately one pound of coal. Such results correspond to an overall heat efficiency, which is very close to that of the gas engine plant. A steam plant to attain such efficiencies must be of enormous capacity and represents almost as complicated an installation as the German gas engine plant with its waste heat recovery elements. The turbine plant, however, by encouraging the adoption of large units, in steel plants, as shown by the installation of machines ranging from 15 to 30,000 kw. at several works, decreases the first cost of the station and makes it cheaper to operate. The largest gas engine built so far in Germany is an 11,000 hp. unit, driving an 8,000 kw. generator, a size which has not been reached by American gas engine builders. The fact that the gas engine station needs the steam turbine for flexibility and equalization of its load, suggests the simpler program of installing the steam turbine plant in the first place

as a central station containing the largest possible units. In the final analysis it is the cost of fuel and labor which will govern the choice of the prime mover.

The Cleaning of Blast Furnace Gas.

Nearly 20 years ago the practice in Germany was to clean all the blast furnace gas mechanically, generally in washers of the disintegrator type. A number of plants have since gone so far as to install the bag filter system, and some the electric precipitation process. At any rate, practically all the blast furnace gas is finely cleaned to .02 grains per cu. ft. or below. In this country it was considered economical to wash the gas only to a degree which would permit the use of about 4½-in. checker openings with 2½-in. or 3-in. wall thickness in the hot blast stoves for which a gas cleaned in tower washers was fully satisfactory and gave the desired economy without complicating the plant or adding to the problem of mechanical upkeep. Neither were the boiler plants developed to a state where the necessity for absolutely pure gas existed or full advantage of its use could be realized; in fact it was a question whether there was any economy in washed gas at all for boiler use, due in part to the fact that the gas was not cleaned enough to prevent coating the tubes. It must also be remembered that at that time 1200 deg. F. to 1300 deg. F. was considered a high blast temperature, the low, steep bosh and large hearth design had not reached its full development, and this average temperature could readily be obtained, with a stove capacity comprising not less than 2 sq. ft. of heating surface per ton of annual pig iron production.

In recent years the use of much higher blast temperatures has generally been found advantageous and is now available at many plants through the use of automatically controlled pressure burners in connection with modern stoves. With these high heats and the amount of dust which remains in the primary washed gas, considerable disintegration of the brick work occurs, so that the useful life of the stove checkers, even if of sturdy construction, instead of being 20 to 25 years, as expected, may not be more than 15 years, in spite of the frequent replacement of top layers. In Germany with gas cleaned to .02 grains per cu. ft., stove designs have been adopted which use checker brick with only 1 inch wall thickness and with openings less than 3 inches square or special fillings having still smaller openings. In this manner very much larger heating surfaces, have been developed for a given dimension of stove, so that their size or number could be substantially reduced. While such methods results in heat economy, it would seem that the greater possibilities resulting from perfectly clean gas lie in the direction of using a material of greater heat conductivity than fire brick, for efficient heat exchange between air and waste gases below a given range of temperature, to replace a portion of the fire brick checkers. Checkers of refractory material must be used and are efficient at the higher temperatures, but a greater portion of the refractory material could advantageously be replaced by metal fillings or recuperative elements.

Advantages of Finely Cleaned Gas.

The great advantage of having perfectly clean blast furnace gas for boilers is apparent today. It should not be applied in any but the finely cleaned

(Continued on page 512)

Effect of Blast Temperature on Pig Iron*

This Paper Covers in Great Detail the Effect of Temperature in
the Blast Furnace on the Properties of Pig Iron—
Results of Numerous Tests Given

By A. WAGNER

FOR some years it has been recognized that the chemical analysis of pig iron is not the determining factor in its evaluation, that moreover different brands of pig iron having the same composition have shown totally different properties on working. For example, the foundryman knows that certain pig irons make castings hard, while other pig irons produce soft castings, in spite of the fact that there may be no essential difference in chemical analysis to account for this. It was thought at first, that oxygen was the cause, but the tests made to-date by E. Schuez† have not confirmed this theory. Reasons suggested from other sources must also be rejected, as they do not offer a satisfactory explanation and to a certain extent endanger the present development of blast furnace science.

Hastening Production Produces Poor Iron.

John Porter‡ blames the poor pig iron properties on the smelting of roll scale, while Venator§ sets up an oxygen theory according to which satisfactory pig iron should be made from easily reduced ores, by not hastening production too much and using sufficient fuel. Moldenke¶ also believes in an oxidation of the iron in its manufacture. Jacques Varlet¹ asserts that special pig irons blown in the large present day blast furnaces no longer have the uniform composition as previously, and even with exact control of the analysis have lower tensile and bending strengths. He traces the deterioration of pig iron back to the use of the hot blast and the mechanical charging of the furnace. The advantages of certain English pig iron brands are supposed to be due to the use of small old blast furnaces, which are still charged by hand and work with low pressure cold blast. Low pressure cold blast is said to be synonymous with slight oxidation in smelting. J. E. Fletcher² ascribes the differences in pig iron properties to almost all the influences that can effect blast furnace operation. It is said that the pre-heating caused by the rising blast furnace gases results in early reduction and melting of the ores and is responsible for the properties of the pig iron.

In an attempt to clear up the influence of the blast furnace process on the properties of foundry pig iron, a questionnaire was sent to a number of blast furnace plants.³ As the various plants brought out the difference in ores and additions, and in some cases the deciding effect of the blast temperature, matters were considerably complicated. This situation was cleared

up somewhat by the intensive investigations of Piwowsky† who found, that foundry pig iron with the same pouring temperature and the same metallurgical and foundry prerequisites solidifies with changing percentages of graphite formation, if only one condition is changed, namely the previously mentioned maximum blast temperature. Based on laboratory tests, Piwowsky shows that apparently every pig or cast iron has a certain marked temperature range, dependent on the chemical analysis, which if exceeded increases the tendency for it to solidify gray. In addition, the test results seem to justify the conception of the simultaneous existence of two kinds of molecules in the liquid state, which upon solidification, have a tendency to promote the formation of graphite or carbide depending upon the preponderance of one molecule over the other.

Overheating Influences Graphite Formation.

After proving in the laboratory that overheating actually influenced the formation of graphite, the next step was to determine the reason for the difference in properties of the same kinds of pig iron resulting from the difference of the blast temperature used. The results of extensive tests on a number of pig iron heats carried out to clear up this question are given below. They were carried out under full operating conditions but with different blast temperatures.

Two furnaces were used—Furnace I was blown with an average blast temperature of 550 deg. C. by means of a Gjeers apparatus, while the blast for the other (Furnace III) was heated in Cowper stoves to an average of 850 to 950 deg. C. Six different heats were taken from each (see Table 1) with approximately the same silicon and total carbon and tested chemically and metallographically, as well as for hardness, tensile and bending strength. The compositions given in Table 2 show slight differences in sulphur, phosphorus and manganese contents. The principal difference of the pig iron investigated was in silicon content. Pig iron with low and average silicon content are used for malleable pig iron, while those with high silicon find favor for special additions in the manufacture of rolls, cylinders, ingot molds and other castings subjected to severe service. All heats investigated were cooled in iron molds as shown in Fig. 1.

From each tap, four tests (two pig and two trough) were taken at random and tested. The possible deviations in analysis with the same contents in the same tap are worthy of note. The diagrammatic representation of graphitic carbon to total carbon, Figs. 2 and 4, shows that with higher blast temperatures and correspondingly pronounced temperature drops in the blast period a considerable scattering resulted. By plotting the results according to increasing silicon content, as shown in Fig. 3, the same carbon and percent-

*Translated from *Stahl und Eisen*, July 29, 1926, pages 1005-1012, by Richard Rimbach, Metallurgical Engineer, Pittsburgh, Pa.

†Personal communication.

‡Foundry Trade Journal, 14 (1912), page 86.

§Giesserei Zeitung 9 (1912), page 283.

¶*Stahl und Eisen*, 33 (1923), page 1813.

¹Fonderie Moderne 19 (1925), Beil., Asso. Techn. Fond., pages 31-38.

²Foundry Trade Journal, 32 (1925), pages 312-2, 341-2 and 373-4.

³*Stahl und Eisen*, 45 (1925).

†Bericht Werkstoffsausschuss, Verein Deutscher Eisenhuettenleute, No. 63 (1925), reviewed.

age parts of graphite appear with Furnace III as a result of the high air blast temperature only with the higher silicon contents.

Tensile and Bend Tests Made.

Tensile and bending test pieces, Fig. 5, were turned from the pig and trough so that every heat was subjected to a tensile and bending test. An investigation

TABLE I—MARKING OF THE TEST PIECES

No. of Test	Pig or Trough	Heat No.	Structure	Test for Chemical Analysis	Test for Microscopic Analysis	Tensile Test	Bending Test
1	Pig	3909	Gray	1	1	1	..
2	Pig	3909	Gray	2	2	..	2
3	Trough	3909	Gray	3	3	3	3
4	Trough	3909	Gray	4	4	4	4
5	Pig	3769	Gray	5	5	5	..
6	Pig	3769	Gray	6	6	..	6
7	Trough	3769	Gray	7	7	7	7
8	Trough	3769	Gray	8	8	8	8
9	Pig	3967	Light Edge	9	9	9	..
10	Pig	3967	Light Edge	10	10	..	10
11	Trough	3967	Light Edge	11	11	11	11
12	Trough	3967	Light Edge	12	12	12	12
13	Pig	3881	Gray	13	13	13	..
14	Pig	3881	Gray	14	14	..	14
15	Trough	3881	Gray	15	15	15	15
16	Trough	3881	Gray	16	16	16	16
17	Pig	3957	Light Edge	17	17	17	..
18	Pig	3957	Light Edge	18	18	..	18
19	Trough	3957	Light Edge	19	19	19	19
20	Trough	3957	Light Edge	20	20	20	20
21	Pig	3987	Light Edge	21	21	21	..
22	Pig	3987	Light Edge	22	22	..	22
23	Trough	3987	Light Edge	23	23	23	23
24	Trough	3987	Light Edge	24	24	24	24
25	Pig	3204	Gray	25	25	25	..
26	Pig	3204	Gray	26	26	..	26
27	Trough	3204	Gray	27	27	27	27
28	Trough	3204	Gray	28	28	28	28
29	Pig	2842	Gray	29	29	29	..
30	Pig	2842	Gray	30	30	..	30
31	Trough	2842	Gray	31	31	31	31
32	Trough	2842	Gray	32	32	32	32
33	Pig	2376	Light Edge	33	33	33	..
34	Pig	2376	Light Edge	34	34	..	34
35	Trough	2376	Light Edge	35	35	35	35
36	Trough	2376	Light Edge	36	36	36	36
37	Pig	3256	Gray	37	37	37	37
38	Pig	3256	Gray	38	38	..	38
39	Trough	3256	Gray	39	39	39	39
40	Trough	3256	Gray	40	40	40	40
41	Pig	3310	Light Edge	41	41	41	..
42	Pig	3310	Light Edge	42	42	..	42
43	Trough	3310	Light Edge	43	43	43	43
44	Trough	3310	Light Edge	44	44	44	44
45	Pig	1242	Light Edge	45	45	45	..
46	Pig	1242	Light Edge	46	46	..	46
47	Trough	1242	Light Edge	47	47	47	47
48	Trough	1242	Light Edge	48	48	48	48

carried out on another occasion showed that directly poured pieces resulted in so great a variation of physical properties that the method was considered unreliable. The turned test pieces show very good agreement, (Tables 3 and 4), and are therefore considered quite satisfactory. The absolute physical properties are relatively low, as they were cast from pig iron of the first melting, but they can not be used for the purpose of comparison without taking this into con-

sideration. The diagrammatic arrangement of tensile tests results and hardness numbers, Figs. 6 and 7, with reference to graphite formation resulting from a change in blast temperatures, is also recognized by the scattering of Furnace III. Fig. 8 shows the scattering of the bend tests values is about the same with both furnaces. The similarity in the average values of the low, medium and high tensile and bending tests with both furnaces is striking.

A careful study of the structure in Figs. 9 to 20, shows no deviation between the two series of tests. The unetched micrographs show the arrangement of the mostly finely divided graphite. The differences in the development of the graphite which is observed with the two furnaces, are a result of the difference between pouring temperature of the pig iron and mold temperature. As Furnace I was no longer in operation at the time of the investigation, corresponding iron temperature could not be determined, and measurements of the tapping temperature were made on other furnaces with different blast temperatures (Table 5). From the tabulation, it can easily be seen that the variations of the iron temperature are independent of the corresponding blast temperature and comparatively small. The influence of the mold temperature will probably be more pronounced, which, as has been proven, can be very different according to the cooling of the pig iron. The deviations in the graphite development observed in these investigations will bring to mind the results of Bardenhauer* which proved that the graphite distribution in cast iron becomes finer, the colder the mold.

The sections which were etched with alcoholic nitric acid to develop the pearlite, show a comparatively pure pearlite ground mass, which, in addition to the fine graphite division, is the sign of a first class pig iron. Free cementite rarely occurs. In most cases it occurs with simultaneous precipitation of fine graphite, and the faster cooling recognized as being the cause for this.

The investigation of the structure checks the results of the chemical and physical tests, that a basic difference in the pig iron properties cannot be proven, due to differences in the blast temperatures.

Uniform Operating Conditions Essential.

A certain irregularity occurs in the composition in the case of Furnace III, especially in the per cent of graphite, which is caused not only by the difference in blast temperature, but also by the comparatively pronounced temperature drop during the blast period. An additional proof for the necessity of achieving the utmost uniformity of all conditions which might influence the operation of the blast furnace.

In this connection, it is expressly pointed out that the so-called "cold blown" pig iron brands were purposely omitted from consideration, as the operating conditions of the ordinary coke blast furnace, particularly the silicon content of the slag, are basically different and a definite composition of pig iron is purposely aimed at. The conclusions drawn here cover only the production of foundry iron with hot blast and normal slags.

Wood and coke blast furnace iron of the same analysis of W. W. Jominy† are also excluded. Micro-

*Mitteilungen K. W.-Inst. Eisenforsch. VI (1924), page 53; Stahl und Eisen, 45 (1925), pages 825-834 and 1022-1027.

†Stahl und Eisen, 45 (1925), pages 843-844.

graphs, Fig. 21 and 22 show the structure of two Swedish charcoal pig iron brands S. T. H. and G. S. H., which check closely in composition and structure with the coke pig iron investigated.

Even the quality of this pig iron, which is used as substitute for charcoal iron, does not approach that of the Swedish pig iron. Attention is called to a paper by Wuest* in which he mentioned that the amount of blast required when the burden was operated with charcoal was only 65 per cent of that required when operated with coke, the same furnace being used in both cases. This can be offered as proof that in the coke blast furnace much larger quantities of iron are oxidized in front of the tuyeres than in the charcoal furnace. In the charcoal furnace, carbon dioxide is changed to carbon monoxide more rapidly than in the

coke blast furnace, therefore, a much smaller part of tuyere level is filled with oxidizing gases than when operating with coke. The correctness of the assumption that the superiority of charcoal foundry iron

	Charcoal Brand S. T. H. %	Charcoal Brand G. S. H. %
Silicon	1.40	1.59
Total carbon	3.85	4.00
Graphite	2.90	3.10
Graphite in per cent of total carbon	75.3	77.6
Sulphur	0.025	0.015

blown with low blast temperature is due to the form of the graphite can not be proven.

Carbon Content Influenced by Blast Temperature.

The fact that the elevation of blast temperature controls the carbon content of pig iron, apparently

TABLE II—COMPOSITION OF THE PIG IRON HEATS INVESTIGATED

Test No.	Si Pct.	Average Pct.	S Pct.	Average Pct.	Mn Pct.	P Pct.	Total C Pct.	Average Pct.	C Pct.	Average Pct.	C Combined Pct.	Average Pct.	Graph C in Pct. of Total C	Average Pct.	Test No.
1	1.76	1.75	0.015	0.011	0.10	0.0613	4.25	4.31	3.10	3.17	1.15	1.14	73.0	73.7	1
2	1.65		0.010		0.10	0.0501	4.30		3.15		1.15		73.3		2
3	1.85		0.010		0.082	0.054	4.35		3.25		3.10		74.8		3
4	1.74		0.010		0.082	0.045	4.35		3.20		1.15		73.7		4
5	1.46	1.55	0.010	0.011	0.092	0.056	4.20	4.19	3.10	3.22	1.10	0.96	73.9	77.2	5
6	1.49		0.015		0.083	0.0495	4.20		3.25		0.95		77.4		6
7	1.81		0.010		0.083	0.051	4.20		3.25		0.95		77.4		7
8	1.42		0.010		0.110	0.063	4.14		3.30		0.85		79.6		8
9	0.95	0.93	0.050	0.053	0.100	0.066	4.15	4.12	3.05	2.91	1.10	1.22	73.5	70.3	9
10	0.81		0.060		0.085	0.061	4.10		2.55		1.15		62.2		10
11	1.06		0.040		0.070	0.072	4.10		3.05		1.05		74.4		11
12	0.09		0.060		0.070	0.072	4.15		3.00		1.15		72.3		12
13	1.60	1.67	0.015	0.015	0.100	0.067	4.20	4.19	3.15	3.06	1.05	1.12	75.0	73.1	13
14	1.67		0.015		0.080	0.078	4.20		3.10		1.10		73.8		14
15	1.59		0.015		0.100	0.068	4.15		3.00		1.15		72.3		15
16	1.81		0.015		0.070	0.078	4.20		3.00		1.20		71.4		16
17	1.04	1.04	0.060	0.055	0.080	0.072	4.00	3.96	2.90	2.88	1.10	1.09	72.6	72.6	17
18	1.04		0.060		0.080	0.067	3.95		2.90		1.05		73.5		18
19	1.04		0.050		0.080	0.075	3.95		2.90		1.05		73.5		19
20	1.06		0.050		0.080	0.072	3.95		2.80		1.15		71.0		20
21	1.17	1.13	0.050	0.054	0.100	0.062	4.10	4.02	3.00	3.00	1.10	1.04	73.2	74.3	21
22	1.17		0.050		0.100	0.067	4.05		2.98		1.07		73.7		22
23	1.11		0.050		0.110	0.058	4.05		3.00		1.05		74.2		23
24	1.04		0.065		0.090	0.061	3.95		3.00		0.95		76.0		24
25	2.13	2.18	0.010	0.012	0.090	0.061	4.15	4.15	3.05	3.02	1.10	1.10	73.6	73.6	25
26	2.18		0.010		0.080	0.062	4.20		3.08		1.12		73.4		26
27	2.16		0.010		0.090	0.058	4.25		3.00		1.25		70.8		27
28	2.23		0.015		0.090	0.069	4.00		3.06		0.94		76.5		28
29	2.19	1.96	0.015	0.015	0.090	0.062	4.20	4.30	3.10	3.25	1.10	1.05	73.7	75.6	29
30	1.88		0.015		0.090	0.067	4.35		3.20		1.15		76.7		30
31	1.95		0.015		0.070	0.070	4.30		3.30		1.00		78.3		31
32	1.79		0.015		0.070	0.067	4.35		3.40		0.95		73.8		32
33	1.42	1.25	0.025	0.024	0.080	0.070	4.05	3.99	2.80	2.77	1.25	1.21	69.2	69.6	33
34	1.15		0.025		0.080	0.075	4.00		2.85		1.15		71.3		34
35	1.23		0.020		0.060	0.073	3.95		2.70		1.25		68.4		35
36	1.20		0.025		0.070	0.056	3.95		2.75		1.20		69.7		36
37	1.95	1.91	0.010	0.010	0.060	0.072	4.20	4.16	3.30	3.30	0.90	0.89	78.6	78.9	37
38	1.95		0.010		0.070	0.067	4.30		3.40		0.90		79.2		38
39	1.87		0.010		0.080	0.094	4.15		3.30		0.85		79.7		39
40	1.87		0.010		0.060	0.064	4.10		3.20		0.90		78.2		40
41	1.20	1.18	0.025	0.029	0.050	0.061	4.05	3.97	2.75	2.75	1.30	1.22	67.9	69.3	41
42	1.17		0.020		0.070	0.061	4.00		2.80		1.20		70.1		42
43	1.11		0.040		0.070	0.061	3.95		2.75		1.20		69.3		43
44	1.20		0.030		0.070	0.061	3.90		2.70		1.20		69.3		44
45	1.04	1.06	0.035	0.038	0.050	0.061	4.10	4.09	2.80	2.76	1.30	1.33	68.3	67.6	45
46	1.17		0.025		0.070	0.061	4.20		2.80		1.40		66.8		46
47	1.01		0.045		0.050	0.061	4.10		2.70		1.40		65.8		47
48	1.00		0.045		0.050	0.061	3.95		2.75		1.20		69.6		48

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contradicts the results of Piwowarsky and earlier investigators. To explain this apparent contradiction, other factors must be studied more closely. In the reactions in the blast furnace more than in any other metallurgical process, the influence of "dry" and "liquid" heat must be considered. It must be pointed out that the average heat content of a ton of liquid blast furnace slag can be assumed as 440×10^3 kilogram calories, while the same amount of iron contains only about 270×10^3 kilogram calories. From these two figures, one recognizes the predominating influence of the fluid heat carrier (slag) as against the "dry"

TABLE III—RESULTS OF TENSILE AND HARDNESS TESTS

No. of Test	Dimensions		Breaking Load			Break	Brinell Hard-
	Diameter in mm	Surface in mm ²	Total kg	in kg/mm ²	Average kg/mm ²		
1	25.0	491	4150	8.46	8.46	Center	157
5	24.9	487	3950	8.12	8.11	Below	130
7	25.2	499	3950	7.93		Above	163
8	23.1	495	4100	8.29		Above	146
9	24.8	483	6400	12.2	12.3	Below	180
11	25.2	499	6100	12.2		Above	187
12	25.1	495	5700	11.5		Above	183
13	25.0	491	5150	10.5	11.5	Above	170
15	25.2	499	6700	13.4		Center	217
16	24.9	487	5100	10.4		Above	156
17	24.9	487	5300	10.9	11.5	Below	179
19	25.0	491	6150	12.5		Center	190
20	24.9	487	5450	11.2		Center	192
21	25.0	491	6900	14.0	11.9	Above	210
23	25.0	491	4800	9.78		Above	156
24	25.0	491	5800	11.8		Above	187
Furnace I			Average		10.6		175
25	24.9	487	5400	11.1	11.4	Above	170
27	25.0	491	5800	11.8		Below	166
28	24.7	479	5400	11.3		Center	170
29	25.0	491	4000	8.15	10.6	Below	170
31	25.0	491	5300	10.8		Below	156
32	24.9	487	6300	12.9		Below	166
33	24.9	487	5750	11.8	11.3	Below	174
35	25.1	495	5450	11.0		Below	170
36	25.0	491	5400	11.0		Above	165
37	25.0	491	5000	10.2	11.0	Center	170
39	24.9	487	5600	11.5		Above	160
40	24.9	487	5450	11.2		Center	163
41	24.9	487	4950	10.1	10.6	Center	170
44	25.2	499	5500	11.0		Center	187
45	24.9	487	3500	7.2	8.24	Center	174
47	25.0	491	4200	8.56		Above	142
48	25.0	491	4400	8.97		Above	134
Furnace III			Average		10.5		167

heat, which passes through the blast furnace in the form of air and gas. The heat balance does not take this into consideration, but starts with the disputable supposition, that the air and gas move in the opposite direction from the charge while the molten heat carrier moves down with the iron. The great importance of the quantity of slag on the pig iron properties is confirmed by a number of practical examples.

Excess Slag Produces Soft Iron.

The well known softening effect of the Buderus iron is due to the pronounced effect of the slag. It is blown with an average of 120 per cent of slag and is

especially desirable for the manufacture of soft, easily worked castings, whose structure must be ferritic. The singular properties of the smelted ores, in this case hematite and limonite, are not responsible for the superiority of the Buderus iron. The foundry iron blown at the Wasseraifingen steel works under similar conditions is also known as a soft pig iron. The

TABLE IV—RESULTS OF BENDING TESTS
Distance between Supports l = 26 cm

No. of Test	Diameter mm	Breaking Load			Deflection mm	Hardness
		Total kg	$c = \frac{P.l}{4.W}$	Average		
2	29.7	700	17.4	17.4	1.6	126
6	30.0	720	17.3	17.4	1.5	126
7	29.9	730	17.7		1.6	130
8	29.8	700	17.2		1.9	130
10	29.9	700	17.2	23.0	1.9	172
11	30.0	950	22.8		2.0	172
12	29.9	930	22.6		2.0	172
14	29.9	1000	24.3	23.5	1.7	154
15	30.1	1070	25.5		1.6	192
16	30.0	860	20.7		2.1	170
18	30.0	1050	25.3	25.1	1.6	170
19	29.9	1000	24.3		2.2	172
20	29.8	1050	25.8		2.2	166
22	29.9	1400	34.1	26.9	2.3	218
23	29.8	850	20.9		2.2	134
24	30.0	1070	25.7		2.2	172
26	29.9	800	19.4	22.1	1.0	140
27	29.9	1000	24.3		2.1	148
28	30.0	940	22.6		1.7	144
30	29.9	750	18.2	22.2	1.6	128
31	30.0	960	23.1		1.7	144
32	30.1	1060	25.2		2.3	149
34	29.9	910	22.1	23.9	1.5	154
35	29.8	1030	25.2		2.2	150
36	29.9	1000	24.3		1.9	160
38	29.9	1040	25.3	27.9	1.5	160
39	29.9	1100	26.8		1.4	149
40	29.9	1300	31.6		1.8	172
43	29.5	950	24.0	25.4	1.1	179
43	30.3	1150	26.8		1.2	160
47	29.9	850	20.7	19.6	2.1	149
48	30.0	770	18.5		1.5	146

TABLE V—INFLUENCE OF BLAST TEMPERATURE ON THE IRON TEMPERATURE

Furnace	Average Blast Temperature deg. C.	Average Iron Temperature deg. C.	Slag	Structure of Iron
IV	735	1440	Good	Gray
IV	730	1420	Medium	Gray
IV	740	1450	Good	Gray, hardly visible
V	570	1424	Good	Edge
V	550	1385	Good	White in spots
V	420	1410	Medium	White
V	520	1420	Good	Edge
V	310	1400-1430	Medium	Nearly white

recognized advantages of certain brands of English pig iron are due only to the large excess of slag or to the smelting of low grade ores.

In all these cases, the operating conditions marked by carrying a high percentage of slag are governed by the peculiarity of the ore situation. The natural consequence is an abnormally high coke consumption with correspondingly high pig iron cost. The blast furnace plants which are forced to buy their ore re-

quirements naturally calculate their burden so that with the pig iron blown, the amount of slag and consequently the amount of coke used will be the least possible. It is, therefore, of the greatest importance that the amount of slag be maintained at the lowest value that will produce a good foundry or hematite iron.

Effect of Temperature Influenced by Composition.

No definite rule can be made in this respect, as the effect of temperature on the graphite and carbide promoting influences advanced by Piwowarsky, which in this case is the amount of slag, is dependent on the chemical composition of the pig iron. The most im-

portant constituent in the softening or hardening property of pig iron is carbon, over which the blast furnace man can exert no influence. It has been proven that in one brand of pig iron from the same furnace the carbon content can vary ± 0.5 per cent. The reason for this change, which will not be discussed further in this article, is to be looked for principally in the presence of undesirable constituents in the charge, as for example lead.

A blast furnace, for example, can be operated for a considerable time with the least permissible slag amount of 40 per cent without disturbance, delivering a satisfactory foundry iron, until the chemical com-

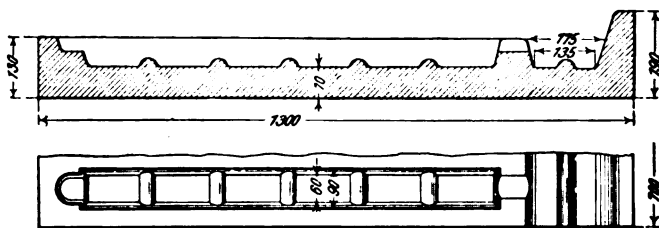


Fig. 1

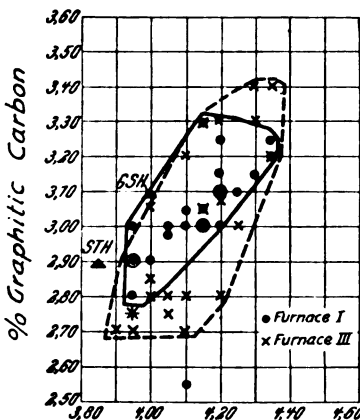


Fig. 2

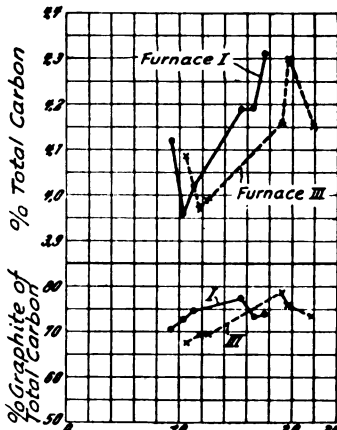


Fig. 3

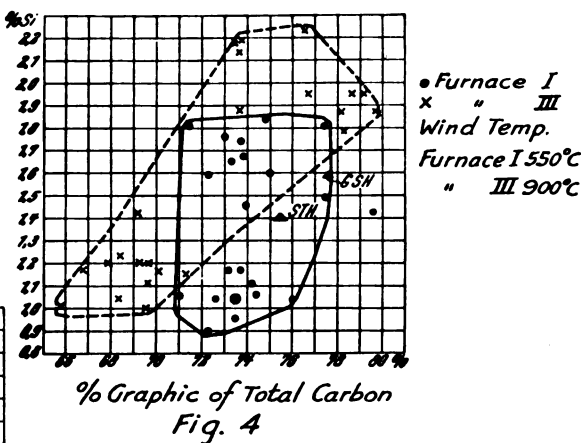


Fig. 4

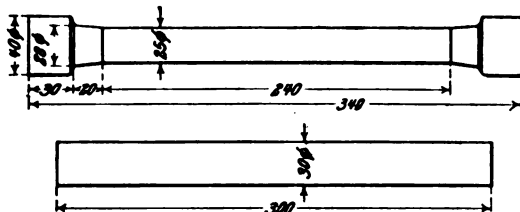


Fig. 5

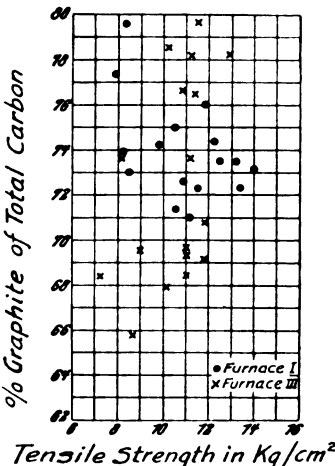


Fig. 6

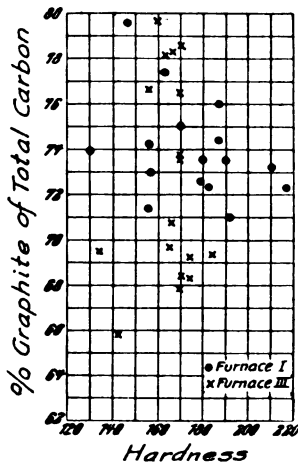


Fig. 7

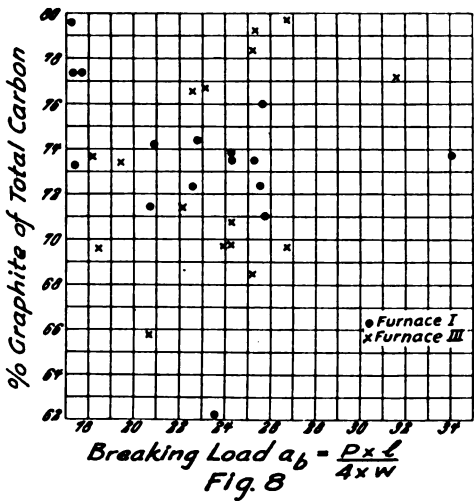


Fig. 8

FIG. 1—Blast furnace casting. FIG. 2—Relation of graphite to total carbon. FIG. 3—Influence of the silicon content on the total carbon blown with different wind temperatures (average values taken from Table II). FIG. 4—Distribution of the graphite percentage with different silicon contents. FIG. 5—Test pieces for tensile and bending tests. FIG. 6—Influence of per cent graphite of the total carbon on the tensile strength. FIG. 7—Relation between hardness and per cent graphite of the total carbon. FIG. 8—Influence of the per cent graphite of the total carbon on the bending strength.

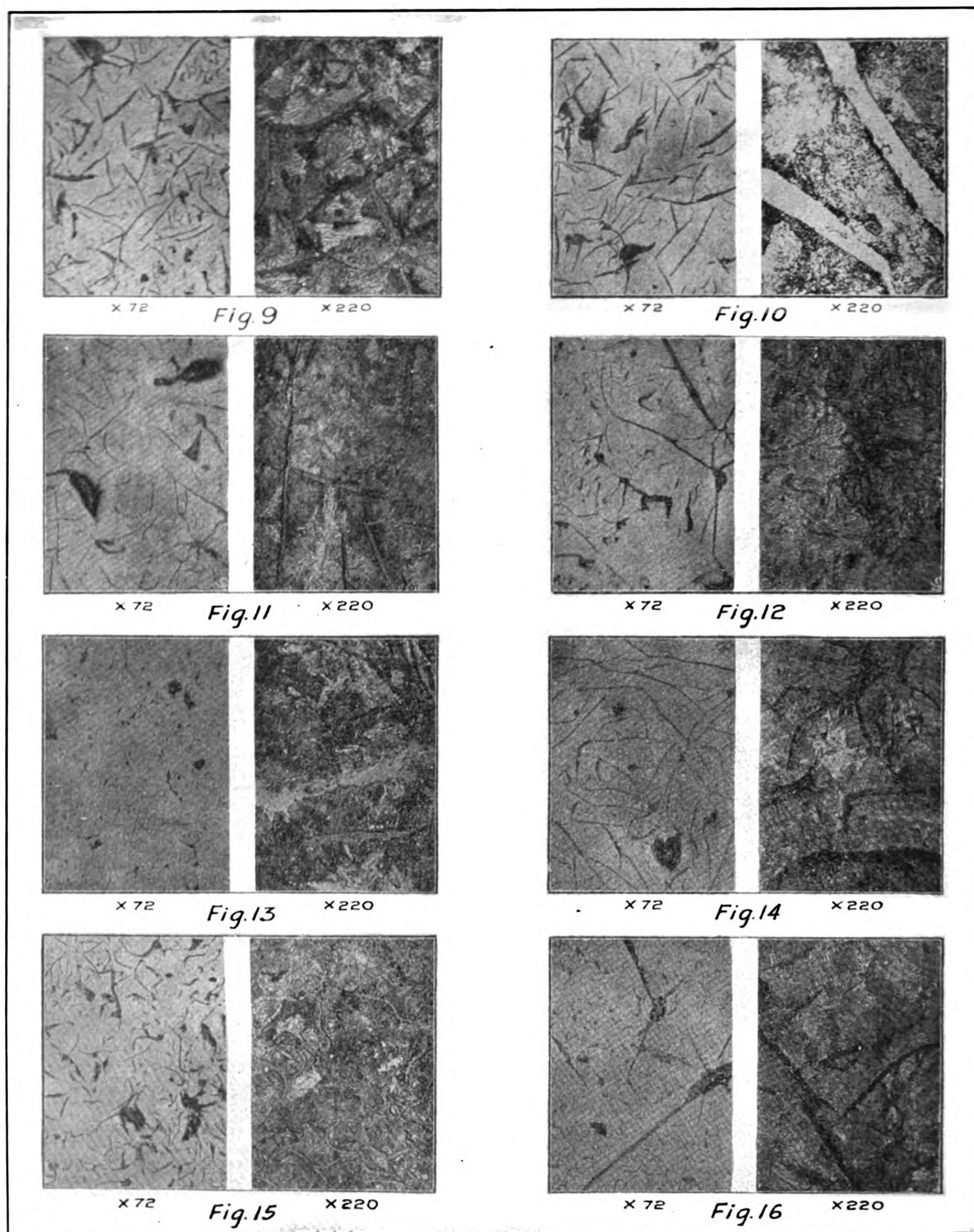


FIG. 9—Furnace I, Test No. 1. FIG. 10—Furnace I, Test No. 7. FIG. 11—Furnace I, Test No. 11. FIG. 12—Furnace I, Test No. 16. FIG. 13—Furnace I, Test No. 18. FIG. 14—Furnace I, Test No. 23. FIG. 15—Furnace III, Test No. 27. FIG. 16—Furnace III, Test No. 32.

(x 72—Unetched. x 220—Etched with alcoholic nitric acid.)

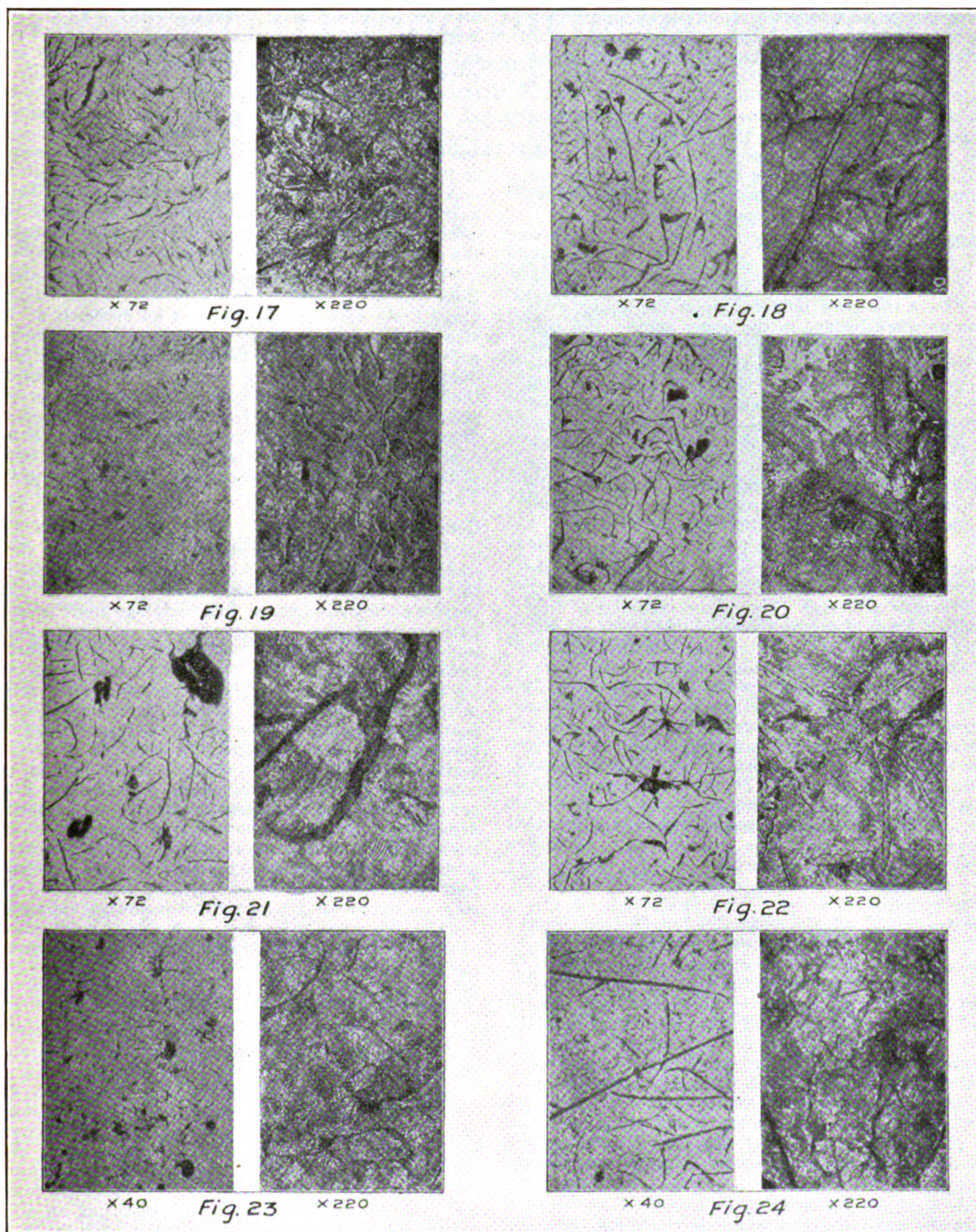


FIG. 17—Furnace III, Test No. 36. FIG. 18—Furnace III, Test No. 39. FIG. 19—Furnace III, Test No. 43. FIG. 20—Furnace III, Test No. 47. FIG. 21—Swedish pig iron. FIG. 22—Swedish pig iron. FIG. 23—Fine grained iron. Total C 4.20 per cent, graphitic C 3.10 per cent, silicon 1.99 per cent, sulphur 0.045 per cent. FIG. 24—Coarse grained iron. Total C 4.40 per cent, graphitic C 3.20 per cent, silicon 2.07 per cent, sulphur 0.045 per cent.

(x 72—Unetched. x 220—Etched with alcoholic nitric acid.)

position of the pig iron changed by the carbon content to arrive at the accustomed graphite promoting effect requires a higher critical temperature range, and, therefore, slag quantity. Scrap pig iron blown in the blast furnace produces a hardening influence if the slag amount is not sufficient.

In addition to the influence the quantity of slag has upon the iron, it appears that reduced iron is subjected to the influence of the liquid slag, that is the time of passage through the furnace, is also an important factor, and investigations are at present under way to determine this influence.

Fusibility of Slag Important.

The fusibility of the slag is also of importance, for if it is formed in the lower portion of the hearth it cannot have the same influence upon the falling drop of iron as when formed in the upper zones. For this reason, increasing the amount of slag by the additions of pyrites and lime is to be avoided, and the use of low sulphur wrought iron slag, which is still available at old slag dumps, is recommended. With this method of working, the middle Rhine blast furnaces can produce an excellent quality of pig iron. The avoidance of low melting slag additions will also have a slight influence on the amount of coke used. The previously mentioned superiority of charcoal iron is probably due to the low melting point of the bisilicate slags.

The importance of the slag composition upon the heating effect shows up especially within certain limits of basicity. A highly basic slag possesses a higher viscosity than acid slag. Under the influence of this viscosity a great heat concentration takes place in the furnace, so that even in certain cases with the high lime slags a large silicon reduction may take place. This is used in a practical way by changing to "hot" iron brands. A high hearth temperature favors the occurrence of large flaked graphite in pig iron, while a reduction of temperature under the same conditions favors the formation of fine lamellar graphite in dense gray iron.* In Figs. 23 and 24, the structures of two similar pig iron brands are compared with other irons, which are different only in the amount of graphite. It is remarkable that the large graphite particles are present in the dense iron, while the iron with the coarse fracture and the heavy graphite veins shows smaller graphite particles. The production of this "loose gray iron," which is desirable for the production of keys, is favored by a strongly basic slag and correspondingly high hearth temperature. Unfortunately, the desire of attaining large flake graphite in quenched pig iron is often frustrated by the previously mentioned harmful effect of lead and other undesirable burden constituents.

Even with the slag amount remaining the same, an undesirable formation of kish graphite may occur in operation if, for any reason in the course of time, an especially large heat concentration occurs in the hearth. This difficulty is successfully counteracted in a blast furnace in the Minette district by using an acid slag.

Insufficient superheat of a pig iron by "liquid" heat in the blast furnace can be equalized by "dry" heat in the handling or working in the mixer or air furnace. In this possibility, to equalize and heat above this, lies the great importance of the air furnace in the production of high quality cast iron. The often occurring irregularities and different hardnesses of the synthetic pig iron produced in electric furnaces, which

is due to the absence of sufficient fluid heat carrier, can also be corrected by a correspondingly longer "dry" heat effect, but the duration and therewith the effect is naturally limited by economy. An insufficient heat effect of the pig iron works out most perceptibly in the production of cast iron in the cupola, as due to the short time taken in passing through it can not superheat the iron equally. The above considerations on the importance of slag amounts and slag compositions in the blast furnace process hold more or less also for cupola operation. At present investigations are being carried out to determine to what extent a certain heat effect (superheat) can be accomplished by changing the slag composition and slag amount in the cupola.

The practical usefulness of the above considerations can be carried over to the production of Thomas (basic) pig iron, as the increase of basicity of the slag can be carried out at the expense of the time of passage through the furnace and therewith the production. According to the viewpoints held heretofore, the physical heat of the Thomas iron depends principally on a speedy passage, so that its pronounced influence can be weakened by a high lime slag. Moreover, a high slag basicity favors an increase in carbon of the pig iron, which is especially undesirable in the Thomas process.

Conclusion.

Pig iron brands of the same composition may show totally different properties on working, the reason for this has to date not been satisfactorily explained. Extensive chemical, physical, and metallographic investigations which were carried out on two irons made under the same operating conditions, but with different blast temperatures, showed that a basic difference in pig iron properties can not be ascribed to the difference in the blast temperature. Regular deviations in composition above all in the per cent graphite due to blowing with highly heated hot blast could not be ascribed to the high temperature itself, but to the comparatively large temperature drop in the blast period. This result apparently contradicts the earlier determinations, that the elevation in temperature controls the form of the carbon content and therewith the property of the pig iron. By means of the heat content values the pronounced heating influence of the slag is shown and proven by means of examples. Second, the melting point as well as the composition of the slag influences the precipitated form and amount of carbon.

Fuel Economy in the Steel Industry

(Continued from page 504)

state especially where modern methods of heat interchange are used.

This points to the advantage of finely cleaning the entire output of blast furnace gas. In most localities this is still done most economically by the wet process. The recent development in this country of a vertical sectional machine which is flexible, requires little space, and in combination with a stationary tower, but little power, is of interest as presenting an alternative to the combination of the tower with the disintegrator type of washer. A gas averaging .02 and never containing over .05 grains per cu. ft. is suitable for use, not only in stoves and under boilers, but for coke ovens and heating and annealing furnaces where a gaseous fuel of low heat value can be applied.

(To be continued)

*Metal Industry, 24 (1924), page 380.

Improved Welding Methods Discussed

American Welding Society Convention at Buffalo Well Attended
—Latest Types of Equipment Exhibited at First International Welding and Cutting Exposition

By HUBERT SMITH

THE sixth fall meeting of the American Welding Society and the first International Welding and Cutting Exposition, Inc., held in conjunction with it, at Buffalo, gave manifestation of the great activity of this youthful organization. The convention attracted welding engineers from all over the United States and Canada and from all parts of the world came men to view the giant industrial exhibits, totaling more than 70 in number and estimated to be worth more than \$125,000.

At one o'clock on November 16, the doors of the Broadway Auditorium opened upon this exposition. Immediately, there entered many delegates to the convention who sought to inspect late developments in welding engineering before the convention itself formally opened.

Two booths immediately attracted one's attention, if only because of the fact that they represented foreign concerns. The first was the exhibit of the Alloy Welding Processes, Ltd., London, in charge of E. H. Jones, managing director.

Alloy Steel Welding Demonstrated.

Mr. Jones gave a demonstration showing the conversion of mild steel in the core of any electrode into any class of alloy required. To deposit high speed steel, he takes a core of mild steel, puts upon it a coating of even thickness, this coating to be made up of tungsten, chromium for hardness; vanadium for toughness in addition to a proportion of carbon. All these are mixed together forming a paste and extruded onto the rod of mild steel. Then the prepared rod when used is so arranged as to strike an arc which fuses the surface of ordinary mild steel and fuses the rods as well, this rod flowing down on the mild steel. By varying the materials of the coating, it is possible to deposit any class of alloy steel called for. Thus the welding material is made as the welding process proceeds. He showed operations of tool making in which high speed steel was deposited for making the cutting portions of tools. In tool making, this process can be used to great advantage, it was said.

Mr. Jones also demonstrated the placing of a special alloy coating on the ordinary steel standard wire used for welding structural steel joints. By the application of this alloy, he claims to be able to nearly double the tensile strength of wire used for all classes of this work. He claims to raise its tensile strength from 41,000 lbs. per sq. in. to 74,000 lbs. per sq. in. He claims that this method also greatly increases the elongation of the material.

Another London firm which offered an exhibit was the Liquid Air, Ltd., in charge of J. A. Lunt, American superintendent.

The exhibit in charge of Mr. Jones drew a steady crowd of observers throughout the day and caused no little comment among visitors.

Structural Steel Successfully Arc Welded.

The outstanding feature of the first day's speeches and discussions was the interest following upon the address of A. M. Candy, welding engineer of the Westinghouse Electric & Mfg. Company, who told of the progress in the development of arc welded structural steel joints.

Mr. Candy related the details of the tests conducted at the Carnegie Institute by the Westinghouse company. He claimed that these tests proved so conclusively that properly designed and fabricated arc-welded connections have merit that a contract was awarded the American Bridge Company to build on this plan a five story 70 x 220 foot mill-type building 80 feet high at the Sharon works of the Westinghouse company.

These tests according to Mr. Candy included 22 specimens typifying various structural joints. He stated the design of column connections offers an interesting study in that continuity may be obtained with arc welding at less expense than with riveted designs. Welded connections, he claimed, are stronger than riveted ones.

According to Mr. Candy, these tests demonstrate that welded joints can be constructed to develop fully the ultimate strength of the structural members connected. Beams and girders can be connected to columns producing absolute fixation, he said. He declared a steel I-beam of given section and length will sustain a far greater load if fixed at its ends by a suitably designed welded joint than if supported by standard riveted connections consisting of top and bottom angles.

Claims Welding Stronger Than Riveting.

It was his contention that a plate girder assembled by welding and consisting only of sheared plates has far greater bending strength than a riveted plate and angle girder of the same weight, due to better distribution of steel in the cross section. The tests proved the entire practicability of welding without any misgivings as to safety, he declared.

On the floor of the exposition stood a large steel frame with all its joints welded. It occupied a prominent position and during each day of the exposition drew much attention from the delegates and other exhibitors. It showed the proper method of welding the different joints and gave a fine view of the process which it seems is going to be prevalent in the building world.

In discussions, the shift from riveting to welding was a prominent topic of conversation. New Yorkers, where the noise of the riveter keeps late sleepers from enjoying their drowsy hours, were particularly interested for this new method of connecting structural steel joints would do much toward making that city less noisy, it was said.

At the annual banquet, which was held in Hotel Statler Thursday evening, the following engineers

spoke: F. M. Farmer, president of the society; George C. Diehl, county engineer of Erie County, representing the Engineering Society of Buffalo, and H. R. Swartley, Jr. It was predicted by Mr. Diehl that the newly developed innovation of welding instead of riveting joints would revolutionize the structural steel industry. Bridge building would also be greatly affected by this new development. The greater strength resulting from the welded joints would allow greater freedom in design and hence enhance the beauty of the buildings also, it was said.

Locomotive Parts Welded.

Railroad men from all parts of the United States and Canada were present at the opening day of the convention, when the welding of locomotive parts and welding on the railroads generally were discussed. G. H. Gjersten, master welder of the Northern Pacific Railway Company, told of the wonderful progress made by the railroads in the last few years in the application of the fusion welding processes.

F. H. Williams, assistant test engineer of the Canadian National Railways, said a tendency had developed here and in Canada toward the adoption of electric welding as standard practice for 80 per cent of the welding and that the balance was left, together with the cutting or most of it, to oxy-acetylene. He spoke of the substantial economies effected through welding as opposed to replacement of engine and tender parts, the saving on a stoker elevator being \$99.96.

Welded Roof Tests Discussed.

Tests on welded roof trusses was the subject of an address by H. H. Moss of the Linde Products Company, who also spoke during the afternoon of Wednesday, the opening day. He stated that during the months of April and May, a series of tests were conducted at the Buffalo shops of their company on some oxy-acetylene welded steel roof trusses. These tests were preceded by studies of this problem during several years, he said. A practical and sound method for fabricating structural steel by oxy-acetylene welding was sought and constructive results have now been obtained, he declared.

Thursday, the second day of the convention, saw the battle of the place of welding in the curricula of universities of engineering definitely threshed out. The speeches began at 10 o'clock in the morning and continued until noon.

Ernest L. Lucas, professor of mechanical engineering in the Mississippi Agricultural and Mechanical College, said that in 1917 a course was offered there in Modern Methods of Welding Metals and that interest in the course grew so rapidly, it was substituted for one semester of machine shop practice.

Welding Instruction for Colleges Advocated.

W. P. Turner, professor of practical mechanics of Purdue University, Lafayette, Ind., stated "the rapid development of the art of welding with its many applications to the manufacturing industries is demanding the attention of engineers in both industrial and educational work and it is worthy of a place in the curriculum of any engineering university."

Professor S. T. Hart of Syracuse University, stated that as welding will be used more and more in the building of bridges, study and experiments should be made for new forms of structural steel. He told the assembly that manufacturers could help along the

task of acquainting embryo engineers with the advance of welding by furnishing speakers several times a year at engineering colleges.

O. D. Rickley, of the Ohio State College, spoke of the fact that since the mechanics of riveted joints has been taught in engineering colleges for years and if welding is to replace riveting, our young engineers naturally must be taught the mechanics and construction of welded joints.

Mr. Rickley, however, called attention to the fact that the welding industry had been developing at so rapid a rate that what is new one day will be obsolete within a short time. He said it had been the practice in colleges to consider a subject only when sufficient accurate data had been compiled from which fundamental principles can be formulated. He said this does not mean that welding will be ignored, but it is to be treated along with subjects of a similar nature.

Exhibition Given on Bronze Welding.

Rudolph Long of Niagara Falls, the first person to weld bronze gave many exhibitions of the feat at the convention Wednesday. As an observer and later as an amateur welder, he learned that bronze could be welded by keeping it free from draughts and welding from the positive side. His contribution, it is said, made possible the welding of turbine runners, saving annually thousands of dollars.

"Mr. Long's first weld was successful and the \$5,000 runners which formerly were a total loss when broken or worn out may now be repaired for about \$500 and made as good as new. One runner, for a 10,000-hp. machine, repaired seven years ago, is still in operation at Niagara Falls.

Thursday afternoon, there was held a meeting of the welding wire specifications committee with C. A. McCune, chairman. Later, a meeting of the American Bureau of Welding was held and the remarkable progress made by the bureau, which is the welding research department of the American Welding Society, was a source of satisfaction to the members of the American Welding Society and the welding industry as a whole. As previously stated, the annual fall banquet was held in the evening of Thursday.

On Wednesday evening, the welding exposition remained open until after 10 o'clock and more than 1,500 Buffalo manufacturers and delegates to the convention were in attendance. Amazement was visible on the faces of many who visited the exhibits as they gazed upon the recent innovations in welding processes and the new uses to which welding had been put.

Welding with Atomic Hydrogen Flame.

Friday was featured by an address and by demonstrations given by R. A. Weinman and P. P. Alexander of the General Electric Company. This address on new methods of welding, some of which make possible welds which can not be made by any other means, drew great interest from the crowd in attendance.

Demonstrations were made of new welding methods through use of machines, not yet marketed, by Messrs. Weinman and Alexander, research engineers. These methods are employed in joining various steels and alloys and an interested discussion followed the reading of the papers, and motion pictures were shown.

"A great variety of welding work has been carried on in the laboratory during the last year with the Atomic Hydrogen flame," said Mr. Weinman. "The

(Continued on page 533)

Research Work at Bureau of Standards*

The Author Briefly Reviews the Research Activities of the
Metallurgical Division of the Bureau of Standards
for the Year Just Closed

By H. W. GILLET†

THE formal annual reports of the Secretary of the Department of Commerce and of the Director of the Bureau of Standards deal with a multitude of activities and can only cover the metallurgical activities of the Bureau in a very condensed form.

A somewhat more complete picture of the work, based on the activities of the fiscal year just closed, may be of interest to the metallurgical public.

Research on metallurgical problems is the chief aim of the metallurgical division and considerable research on subjects of metallurgical interest is done by the divisions dealing with chemistry, mechanics, heat and power, weights and measures, electricity and ceramics.

Routine testing in chemical mechanical and metallurgical lines is done only for government departments, inquiries from the public for routine tests being referred to commercial laboratories specializing in those lines, lists of such laboratories being available as letter circulars. The Bureau concentrates upon the development of methods of testing and upon securing new fundamental information by research.

That this is the case can be seen from the subjects of the reports issued or prepared for publication during the past fiscal year. All these are or soon will be available in printed form‡ and need no detailed comment here. The titles include the following from the division of metallurgy initial temperatures and mass effects in quenching; characteristics of quenching curves; determination of oxygen and hydrogen in steel; oxygen content of coke and charcoal iron; origin of quenching cracks; dimensional changes in tempering and aging tool steel; etching reagents for alloy steels; effect of nickel, cobalt, tantalum and molybdenum on high speed steel; flow in a low carbon steel; methods of test in relation to flow of steel at various temperatures; scratch hardness testing; corrosion testing; testing of screen wire cloth; effect of manganese, silicon and phosphorus on the pearlite interval; effect of phosphorus in wrought iron made by different puddling processes; avoidance of softness in carburizing; lead filings and zinc dust as pipe jointing materials; tensile properties of soldered joints under prolonged stress; a laboratory high frequency vacuum furnace; protection of iron by cadmium; internal stress in brass tubing; recrystallization temperature of electrolytic iron; transformation of austenitic steel; phenomena accompanying the presence of hydrogen in steel; silicon as alloying element in structural steel; comments on Swedish steel practice; properties of pure zinc at normal and elevated temperatures; the application of heat-treated steels

to industrial uses; the behavior of steel under repeated stress; "Crystallization" of metals under repeated stress an erroneous term; corrosion resistance of certain types of iron and steel; metals to resist corrosion or high temperatures; refractories for use in melting the pure metals, iron, nickel, platinum; etc. Work on methods of sand testing and on welded rails is included in committee reports of the American Foundrymen's Association and the American Welding Society, and much Bureau work is reported by committees of the American Society for Testing Materials.

Other divisions of the Bureau have published articles on: Methods for measuring polarization and resistivity; nickel plating zinc base die castings; protective value of nickel plating; nickel electrotyping solutions; chromium plating; determination of aluminum in non-ferrous alloys; determination of uranium; analysis of dental gold alloys; relation between metallurgical and atomic structure; tests on welded pressure vessels; how to investigate welded tanks; experimental work in design of the Delaware River Bridge; strain detection in mild steel by wash coating; strength and deformation of structural steel and cast iron up to 50 deg. C.; fire tests with sheet steel garages; non-destructive testing of steel wire rope by magnetic analysis; comparative slow bend and impact notched bar tests on metals; elastic ring for verification of Brinell machine; comparative tests of American and German fire-clay brick; thermal expansion of tungsten; phosphor bronze helical springs; enamels for sheet steel; effect of wear on magnetic properties and tensile strength of steel wire; while a paper on tests of large steel columns with H-shaped sections is in press and papers on zinc plating, and on fatigue of sheet duralumin and on the relation between Brinell and Rockwell hardness numbers are in preparation.

Reports describing work of the metallurgical division that is wholly or practically completed, are being prepared for publication on the following: Wear of steels with particular reference to plug gages (in co-operation with the Gage Steel Committee, the Army and the Weights and Measures Division); silver alloys and their resistance to tarnish (in co-operation with the Bureau of Mines); machineability of alloy steels in roughing cuts (in co-operation with the Navy); determination of oxygen in pig iron by hydrogen reduction in presence of Sb-Sn (in co-operation with a Research Fellow); a new alloy for Brinell balls.

Work is well advanced, but not yet sufficiently complete for immediate publication, upon: Methods for determination of nitrogen in metals; methods for determining "blow-hole" gases in metals (in co-operation with Research Associates); laboratory methods for accelerated corrosion testing of non-ferrous metals and alloys (work for American Society for Testing Materials Committee). Other projects upon which large amounts of data are in hand, but upon which

*Published by permission of the Director of the National Bureau of Standards.

†Chief, Division of Metallurgy.

‡A list showing where these articles were published will be sent on request to the Bureau. Some are Bureau Scientific or Technologic publications, others appear in technical journals such as those of various national societies.

further extended investigation will be required before publication can be made are: Quality of steel for carburizing (abnormal steel), (in co-operation with the Bureau of Mines, manufacturers and users); air-hardening steels (for the Army); failures of fusible plugs for steam boilers (for the Steam-boat Inspection Service).

Still other projects of the metallurgical division which are active but will require another year or more of work before completion of the present phase are: Intercrystalline embrittlement of duralumin (for Navy, Army and National Advisory Committee for Aeronautics); laboratory methods for accelerated corrosion testing of zinc-coated materials (work for American Society for Testing Materials Committee); wear resistance and properties at working temperatures of railroad bearing metals (with a Research Associate); prevention of blistering of enamel upon cast iron, (work for American Ceramic Society, and in co-operation with the ceramics division); high temperature properties of metals and methods of high-temperature testing, (work oriented with that of the joint committee, American Society for Testing Materials and American Society of Mechanical Engineers); properties of pure metals, iron, nickel, thorium (in co-operation with other divisions and with commercial firms); methods for testing molding sand (for committee of the American Foundrymen's Association); vaporized metal coatings (co-operative with the Navy and Army); density of carbon and alloy steels after different treatments (co-operative with the weights and measures division); electrolytic methods for corrosion testing; improvements in methods of melting and

working metals of the platinum group; (the last two co-operative with the chemistry division); metallographic properties of ferrite; and solubility of carbon in ferrite (with Research Associates); quality of rail steel as related to soundness of ingots (co-operation with railways and commercial firms); X-ray study of crystal structure; temperature distribution in quenching; iron-nitrogen alloys.

Other projects on which some work has been done and which will be continued or which are scheduled for prompt attention are: Transverse fissures in rails (for joint committee of American Railway Engineering Association, Rail Manufacturers, Civil Engineers, etc.); magnesia refractories for electric steel furnaces (for Navy); antimony-lead storage battery alloys (with the electrical division); specific heat and fluidity of cast iron (with a Research Associate of the American Foundrymen's Association and the heat and power division); wear resistance of babbitt metals (for an American Society for Testing Materials Committee); fatigue properties of rail steel. Work on variables affecting the hot-galvanizing process and its products has been urged by many and is being considered for future study.

Other divisions of the Bureau have work in progress on: Electrical conductivity of aluminum; magnetic testing of metals; pyrometry of molten brass; specific heat; fire resistance; general pyrometry; spectroscopy; assay of gold-filled articles; determination of slag in wrought iron and steel; standard samples for analysis; electroplating; copper roofing; mechanical testing methods and calibration of apparatus; structures for aircraft; welded rail joints; elastic prop-

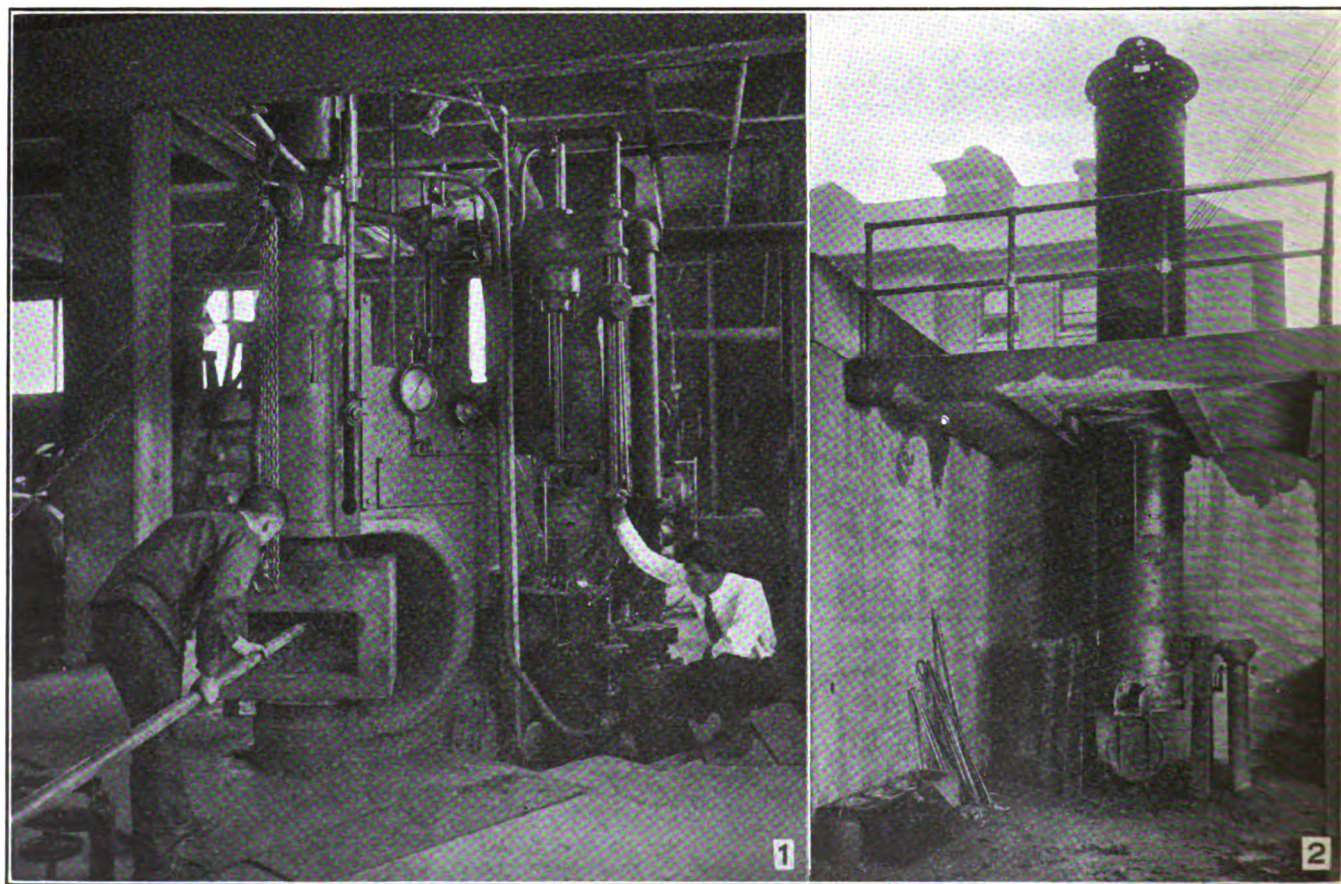


FIG. 1—Shearing a bar in the press, metallurgical laboratory, Bureau of Standards.

FIG. 2—Experimental cupola, Bureau of Standards.

erties of ship steel; high speed fatigue testing; refractories.

Many activities of the Bureau outside of research, such as co-operation with the Federal Specifications Board and other bodies in preparation of specifications, and the development of the "certification" plan as well as the wide-spread activities of the Division of Simplified Practice and of the Division of Building and Housing, have to do with metallurgical products.

Other activities outside experimental research include: Testing bearing metals for the Fleet Corporation, a failed air plane propeller for the Post Office Department, the corrodibility of steel pens for the Federal Specifications Board and a myriad of other miscellaneous tests for the government, together with

culars of information, either printed or mimeographed, prepared from time to time.

The metallurgical research falls into four groups: First, that taken up at Bureau initiative and on Bureau funds (save for contributions of materials for test or study) on the basis of the requests of industry or its own vision of the fields in which fundamental studies should be made; second, that at the request or suggestion of other government departments, especially the military establishment, chiefly problems relating to national defense and partly supported by funds transferred by the department requesting the work; third, that requested by national, technical or scientific organizations, notably the American Society for Testing Materials. Only rarely are Research Associates

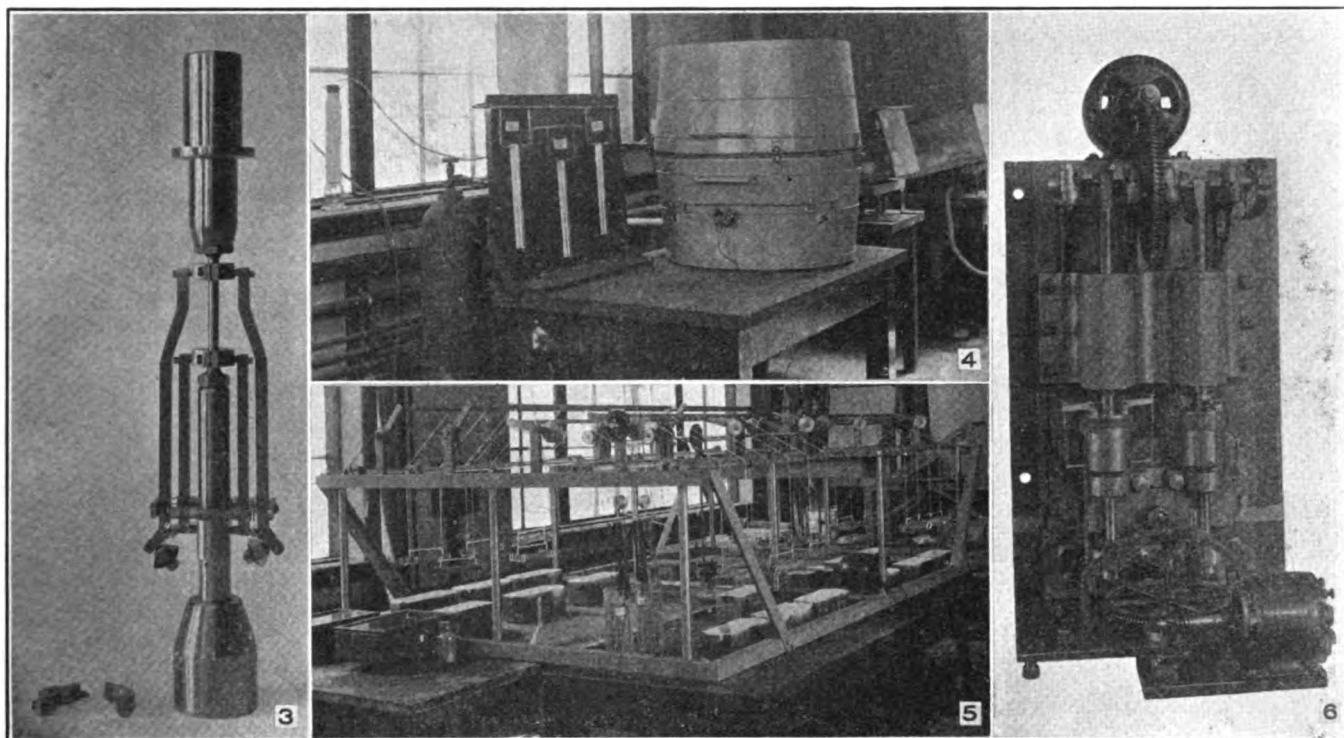


FIG. 3—Special extensometer built at the Bureau of Standards for use in tensile tests at high temperatures. The extension is read with an auto-collimator. The apparatus measures to four millionths of an inch. **FIG. 4—**Apparatus for accelerated weathering test of zinc-coated sheet in an atmosphere of sulphur dioxide, carbon monoxide and water vapor. Salt spray test cabinets in background. **FIG. 5—**Interrupted immersion corrosion testing apparatus used in study of the embrittlement of heat-treated duralumin. The pots holding the corroding media were cast in the foundry of the metallurgical division and enameled by the ceramics division. **FIG. 6—**Wear testing machine used in the study of the life of plug gages.

making the castings and performing the heat-treatment and mechanical working of metals required in making instruments in the Bureau shops for use in research, such work utilizes the metallurgical equipment of the Bureau and the experience of its staff. Many of the tests for other government organizations are quite extended and approximate small research projects. Such for example, was the survey for uniformity of a series of Invar tapes for the Coast and Geodetic Survey, in which it was necessary to make over 10,000 readings of Brinell impressions, in one phase of the work.

The metallurgical experience of the Bureau is also drawn upon in its service work to the public in answering requests for information by letter and from visitors. Every effort is made to serve as a clearing house of metallurgical information, and to this end current metallurgical literature is indexed, and cir-

provided, although raw materials are often supplied and much co-operation is given by committees.

The fourth class is that taken up at the request of individual firms or groups of firms and in which the firms bear part of the expense by paying the salary of one or more Research Associates who work under Bureau direction upon fundamental problems of immediate interest to the firms supporting them, and of general interest to the industry.* This offers a means by which the extensive laboratory and library facilities of the Bureau, a good deal of which must lie unused much of the time for lack of funds and personnel to keep them all constantly utilized, may be brought into greater service to the industry. If the scope of the

*The Research Associate plan is fully described in Circular 296 of the Bureau of Standards, obtainable from the Superintendent of Documents, Washington, D. C., for 10c, stamps not accepted.

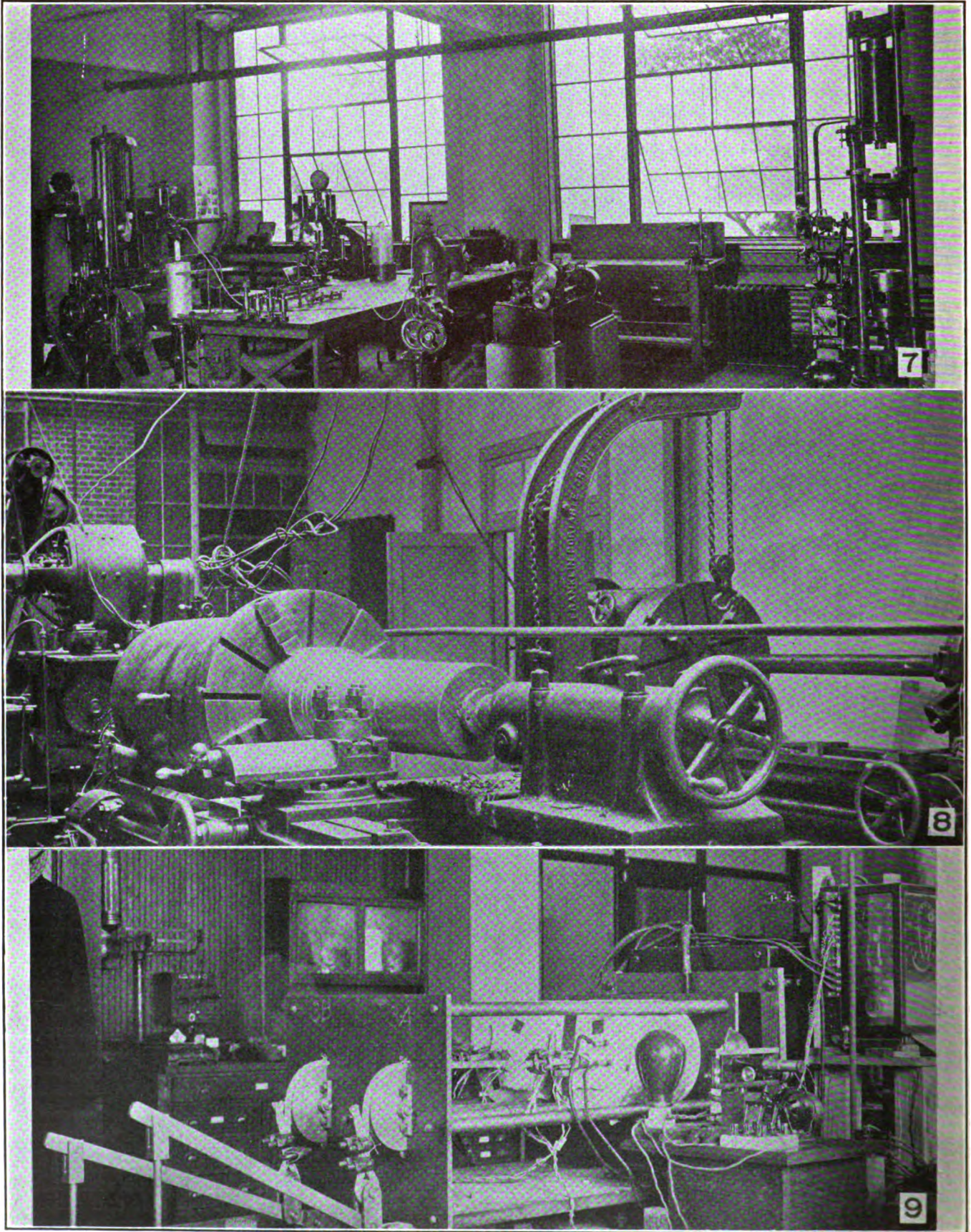


FIG. 7—Laboratory for tensile, hardness, and wear testing. The Amsler wear-testing machine is mounted on the concrete pedestals. FIG. 8—An alloy steel "log" being studied for ease of machining in roughing cuts. FIG. 9—One of several units used in study of the load-carrying ability of metals at high temperatures.

metallurgical activities of the Bureau is to be widened to cover new problems as they arise, this scheme offers the only way out of the difficulty brought about by ever-increasing calls upon the Bureau for service in fundamental research, at a period when increased appropriation of public funds for such service is precluded by the necessity for adherence to the economy program of the government. It is expected that this class of work will steadily increase.

The more important fields of metallurgical endeavor in which a continuing program has been laid out may be summarized as: Study of methods of test of metals for resistance to corrosion and to wear, and for high temperature service; study of methods of testing molding sand, of determination of gases in metals; study of pure metals and their alloys, of bearing metals, of rails, of high speed steel; of machineability; of the fundamentals affecting the metallographic properties, mechanical working and heat-treatment of metals, especially the quenching process. The particular phases of these projects and the succession of other projects that are taken up from time to time are carefully considered by the Metallurgical Advisory Committees whose counsel is of great service to the Bureau.

To state what has been accomplished in the way of establishing new facts through the various research projects which have only been described by title would require much space. All facts so discovered hold for definite conditions and there is grave danger of mis-

understanding in stating the facts without opportunity to define the conditions in detail, as they will be when full publication is made. With the reservation that further work or full details might modify statements that may appear too sweeping because of their brevity, some of the interesting points recently found in work as yet unpublished are given below:

In tests made in a new type of testing machine designed and constructed at the Bureau, on wear of gage steel, chromium plated plug gages are found remarkably superior in resisting metal-to-metal wear, while, some file-hard gages appear less resistant than those of corresponding steels treated so that they can be touched with a file.

The study of "abnormal" carburizing steel shows that the aluminum content, spectroscopically determined, has a marked relationship to the degree of abnormality, though it is more likely concomitant with the real cause of abnormality rather than itself the actual cause. The content of dissolved air in water used for quenching has a marked bearing on the prevalence of soft spots in the case.

Up to one per cent of tin appears to be harmless in high speed steel as far as performance in roughing cuts goes, though other properties may be injured. Nickel up to 3 or 4 per cent, makes a high speed steel require a higher hardening temperature, but does not injure performance. It makes the high speed steel itself difficultly machineable in the annealed

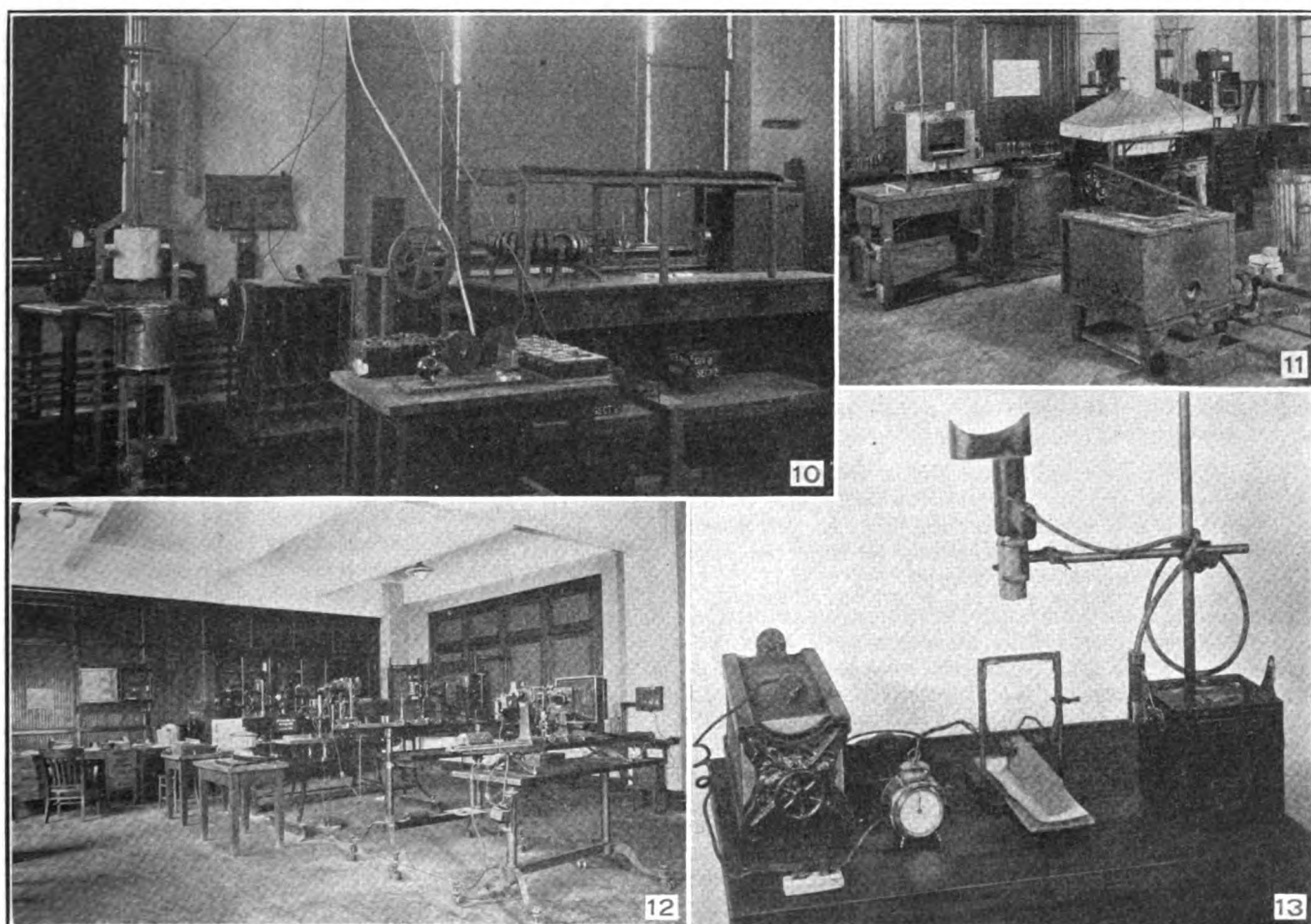


FIG. 10—Apparatus for study of quenching media and of the temperature distribution in a steel specimen during quenching. FIG. 11—Corner of one of the heat-treating laboratories. FIG. 12—Part of the metallographic equipment, Bureau of Standards. FIG. 13—Apparatus for determination of the sintering point of foundry molding sands.

state, but if the carbon content is reduced from the customary 0.65 per cent, this is overcome while their good performance is still maintained.

The relative machinability of alloy steels, in roughing lathe cuts, varies with the hardness at which the steels are compared. At low hardness chromium steels are less readily machineable than carbon or nickel steels. At high hardness nickel chromium and chromium molybdenum are more readily machineable.

Longtime "creep" tests at high temperatures indicate that the load-carrying ability of some high-chromium steels is not as good at temperatures of 1100-1350 deg. F. as that with which they are usually credited. If a suitably sensitive extensometer is used in the short time tensile tests accurate determinations of proportional limits at high temperatures give, on several types of steels, useful approximations of the load-carrying ability. Apparatus measuring strain to four millionths of an inch is used which was designed and constructed at the Bureau.

An alloy of iron containing about 13½ per cent vanadium, and 3 per cent carbon, made into Brinell balls and suitably heat-treated shows only about half as much flattening during the Brinell test as an ordinary ball and about the same as the Hultgren work-hardened ball. The balls can be work-hardened, after which they show only half the flattening of the Hultgren ball. A steel reading 650 Brinell with a Hultgren ball, will read 695 with the work hardened vanadium ball.

The method of analysis of pig iron for oxygen by fusion with antimony-tin alloy in a current of hydrogen shows large blank corrections and low precision and is considered inferior to the vacuum fusion method.

It is possible to drill metal containing minute blow-holes under mercury, collect the gas, and, in a special "micro-pipette," analyze approximately even so small an amount as a quarter of a cubic centimeter.

As much as 300 per cent variation may be found in determinations of scratch hardness by the "micro-character" made by different observers, and they may even class materials in a different order of hardness. The method is useful chiefly as a rough approximation when no better method is applicable.

An alleged new transformation in iron below A_3 , reported by an Italian investigator, was not found when his work was repeated at the Bureau, but there are indications that the phenomenon he reported may be due to a reaction with hydrogen.

Duralumin, used in aircraft, is subject to embrittlement due to intercrystalline attack, a type of corrosion. Some people feared that the loss of the Shenandoah was due to weakening from this cause, and advocated abandonment of duralumin aircraft construction. Exhaustive tests on materials from the wreck showed that this fear was unfounded. Nevertheless deterioration from this cause, if it advances far, may be very dangerous and prevention of or protection against such embrittlement must be attained to utilize the full value of this light alloy; Nitrates, as from the salt baths used in heat-treatment are harmless, but chlorides, which may be present, as in sea-air or hydrogen peroxide possibly formed by the action of light, cause rapid attack. On this action accelerated laboratory test methods are based.

Tentative conclusions, that improvement can be made by use of another alloy of the duralumin type, or by adjustment of the composition and heat-treatment, and that complete protection may be afforded by impervious coatings, with varnish, bitumastic enamel, anodic coating in chromic acid solution, or by a metal-sprayed coating of commercially pure, unalloyed aluminum, these increasing in effectiveness in the order given, which conclusions were made on the basis of laboratory tests, are being checked by exposure tests.

A lining of electrically sintered magnesia bonded with the same material hydrated by grinding in a ball mill with water and baked at a very high temperature has stood up in a small (100 lb.) electric arc furnace for 70 heats of steel and 60 of cast iron without apparent deterioration. A larger furnace is now being similarly lined.

Crucibles made of chemically pure magnesia which is shrunk by heating electrically and bonded with magnesium chloride are used for melting pure iron and pure nickel without contamination.

Testing the molding sand used in foundries is proving of great value, but some of the present test methods are tedious or the apparatus expensive. At the Bureau a permeability tester has been devised using a Pyrex glass orifice instead of one of gold and having other simplifications. A cheap spring compression tester designed to avoid over-running the point of failure has also been devised, and bids fair to take the place of the present bar test for bond strength. To replace the present tedious method for determination of clay the use of a common motor driven "milk-shake" stirrer, suggested by others working on sand testing, has been combined with the scheme of settling the sand in an up-ended glass fruit jar with the bottom cut off. The sand settles into the cap which is removed, the water poured off and the sand dried in the cap.

The refractoriness of a sand, i.e., the way it burns or sinters into the casting, is an important property of a molding sand, but ordinary fusion tests do not show this property. The Bureau has devised and is studying a true sintering test, which shows promise, in which the behavior of the sand is observed when in contact with a platinum ribbon, electrically heated to the desired temperature.

The use of a glycerine or ethylene glycol spray coating as a "facing" for molds acts to prevent burning on of sand, and is being studied.

Tests of a German structural steel of about 0.12 per cent carbon, 1 per cent silicon, indicate it to have a very good combination of high yield point and high ductility. While quantity production of this exact composition has not been undertaken outside Germany, the steel is not new, its properties having been fully described 14 years ago.

The idea, common among the enameling trade, that Northern pig iron is necessarily prone to blistering of the enamel, on the first melt of the pig, but that it improves on remelting appears to have little basis in fact. It seems probable that blistering of enamel is connected with blow holes and unsoundness of the casting, and this may perhaps be related to such factors as fluidity of the iron.

Even 2 per cent of nickel, lead, antimony or aluminum can be added to the 88-10-2 bronze casting alloy

(Continued on page 534)

Plate Mill Developments and Tendencies*

Recent Developments and Tendencies in Methods and Equipment
for the Production of Plates Comprehensively Reviewed
—Keen Competition Has Lowered Prices

By F. M. GILLIES†

PROBABLY the oldest of all rolling mills in a broad sense of the term was a plate mill. This does not mean that back in the dark ages of industrial enterprise plate mills existed and hot ingots or slabs were rolled into plate, but it does mean that the earliest historic records of rolling processes tell of the rolling of flat material. These records date back as far as 1495, and hazy historical data can be discovered farther back, but 1495 certainly is far enough to permit us to assume that sufficient time has elapsed to work out and overcome most of the problems to be encountered in the rolling of flat material. The experience of ages must have had its effect, for the manufacture of plate today has remained in principle comparatively static as compared with our earliest dependable technically described methods.

When Bernard Lauth brought out the three-high mill in 1864, with the small diameter middle roll working between two larger top and bottom rolls, a historic change did take place and production on the three-high units showed a considerable increase over the conventional method of that time of employing two-high stands driven from the same engine, one to rough on and one to finish with; the roughing mill using a roll without chill which was called the soft mill and the finishing stand employing the chilled surface to secure the finish. Lauth's idea had little in it that could be termed a change in method of plate manufacture, although the smaller middle roll was a progressive step. His idea was rather to get away from the cumbersome reversing steam drives of that day, and to take advantage of the single-way drive and its important fly-wheel power. In this way he expected greater rolling speeds and greater tonnages without higher powered drives. His expectations were realized and surpassed and the three-high plate mill was the beginning of a new era in the manufacture of this commodity. It is well that the three-high plate mill came when it did, for it would be difficult to speculate how in years to follow the old method could have met the pressing demand existing even at that time in plate-producing centers. The three-high mill has met the requirements and has carried us to the present, when the demand for steel plate is greater than at any other time in the history of the industry, for indications are that the production of sheared and universal plate will be in excess of 4,300,000 tons in the current year, which will be the heaviest production ever turned out.

Plate Production Exceeds Other Commodities.

When we consider that the tonnage of sheared and universal plate produced each year exceeds the production of other important commodities such as wire rods, shapes and rails, the plate mill appears in a more important light as being a place where it is entirely possible to realize a profit or suffer losses. Since the

war 24,096,231 tons of sheared and universal plate have been produced as against 20,205,211 tons of shapes, 18,337,547 tons of wire rods and 17,283,658 tons of rails; this, too, in a period when plates have been generally supposed not to be in great demand. Certainly a comparison of this kind is sufficient to prove that plates are important enough to warrant consideration.

Since the war the consuming trade, according to average annual price lists, has spent over \$1,250,000,000 for plates. This indicates that the plate trade is of no small dimensions and that it is deserving of much thought in method and means of producing better quality at lower cost. This idea of better quality at less cost in a business spending an average of \$178,000,000 annually has developed improvements and will continue to develop them as long as there is need for them.

Use of Electrical Equipment Increasing.

The most outstanding of the recent improvements is the electric drive and the use of electrical equipment in the general mill work. The word recent may be misleading in speaking of this improvement, for the year 1907 marks the beginning, but the start was slow and the new mills built in the war time and those changed over since the war are the recent cases which I bear in mind. We will not go into a description of the drives and their benefits; much has been said already by others on this topic. It is sufficient to say that the advantages of electric drive are no longer a matter of discussion for it is generally conceded that whenever a steam drive is replaced by an electric, the production of the mill is substantially increased. The question arises in my mind here as to whether this truth exists because of the fact that the electric drive is superior in power or because engineers have been more liberal in their calculations of power requirements on mills to be equipped electrically. I can see no reason why steam as a source of power could not turn out the same tonnage as an electric motor of like size. However, there are many supplementary difficulties that are overcome, and the additional economies gained by electricity are important and deciding.

Design and Layout of Buildings Improved.

Improvement in design and layout of buildings used in the manufacture of plate have been brought out. There are five departments in the process and each of these departments has its own requirements in the way of space, crane equipment, and light. The five departments, heating, rolling, marking, shearing and shipping, all have their well-defined limits and they should be naturally provided for in the arrangement of the building. The prime requisite of the furnace or heating building is to have ready and rapid access from the furnaces or soaking pits to the mills. In this way heat is not wasted and cranes, roller tables or slab buggies are not required to make long hauls, which mean increased upkeep costs and greater chance

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for delay. For this purpose, then, the transverse type of building at right angles to the mill and runout building is the best suited. The new mill buildings, or the rolling portion of the mill building, are high and well ventilated. This allows the heat to rise, steam to quickly clear the mill, and the increased light permits better workmanship on the part of the men. Directly in line with the rolls, and runout which includes a flattening machine, comes the cooling bed; and still in line comes the marking bed where the plates are sized up, and the painting, stamping, etc., are taken care of. This building is usually of the same width as the upper end where the mill is located and is usually better lighted to facilitate more accurate work on the part of the markers, and better ventilated to allow more rapid cooling. At the end of this marking table comes the shearing department and here the building widens out to permit sufficient spacing in the grouping of shears to turn long plates. The modern type of this building also has advanced in the provision for light. From the shear room the new development is to deliver the finished plate into a separate building or bay, usually parallel to the shearing building, in which the shipping department handles its work, which in the present-day status of hand to mouth buying can be rightly called a warehouse. The operators have long labored under the condition of conflicting requests of shears and shippers for cranes and the separate building has been a benefit to both departments. The separate shipping building has facilitated and made more safe the individual plate inspection by inspectors who are called in to go over waiting material, and numerous other excellent benefits have been gained.

The production of plates in the new type of buildings has made strides both in the quality of the product and the cost of production. This has been an improvement by evolution and few layouts can be found with all these improvements included, but they all exist in certain places and have had their good effect.

Little Improvement in Heating Furnaces.

Advancement in the heating end of the mill has been more in the kinds of fuel burned and methods of burning them than in the design of furnaces. The regenerative type of sand bottom furnace is still prevalent and has been so for a long enough period to certainly escape the caption of recent development. The continuous type of furnace with recuperators has given good results in places although the recuperative type of this furnace has given way to the direct draft type in some cases. Here the water-cooled skid with its cold spot left on the slab is undesirable. The continuous furnace with the hearth at the discharge end to eliminate the cold spot has not proven an altogether satisfactory idea and almost presents an insoluble problem in heating heavy wide slabs. Continuous furnaces on mills where cold slabs are charged have relieved operators of bottom trouble to some extent, and the principle in which the slab progresses from a preheating temperature at the charging end to a high temperature condition at the point of discharge we believe to possess merit in comparison to charging a cold slab into the hottest portion of a furnace from where a slab at rolling temperature has recently been drawn.

Producer gas, pitch, oil, blast furnace gas, coke oven gas, tar, pulverized coal and natural gas have

been used recently, as well as combinations of these. We find that certain fuels have shown economies over others, but steel plants adopt fuels for heating to accommodate local conditions in most cases. That is, plate mills attached to plants with coke ovens utilize the by-products and credit the production of coke at market coal equivalent figure in Btus. Two manufacturers have tried using blast furnace gas mixed with other gas of higher heat value with resulting operating success and economy. Pulverized coal has been successful for one plate producer and has succeeded in cutting in half the previous heating cost on oil in this particular mill.

Equipment for the burning of liquid fuels has not arrived at a point of stability. Each fuel engineer or mill superintendent has worked out his own ideas, and personal enthusiasms have made dependable data hardly available. Difference in geographical location has so much to do with fuel costs that to compare heating costs of the various plate makers needs more than just going into the figures. However, of this we are certain, most plate makers are heating their slabs or slab ingots cheaply or more cheaply than ever before. This indicates development, for even with the increasing cost of fuels we do not believe that any producer has found his heating costs have increased and we hear of many cases where they have been materially reduced.

Introduction of Roll Grinder Beneficial.

The mills proper have experienced little change recently. The advance in roll turning, brought about by the introduction of the plate roll grinder, has been a greater benefit to the rolling than anything recently developed in this end of the manufacture. The grinding machine does extremely accurate work and does it quickly, and entirely eliminates the necessity to depend on roll turners, who vary greatly in ability. Mill conditions are made more standard because of this mechanical method, for the grinding machine will produce the same result on each roll, while irregularities are often produced on the surface of rolls turned in a lathe. These irregularities make the mills very difficult to operate. Accurately tapered rolls, always a difficult thing to produce in a lathe, can be produced in a grinder with ease on a very flexible basis. To further explain what is meant here; most mills have a certain standard set of tapered rolls which are made up for a week's rolling or whatever period the main rolls of a three-high mill are allowed to work without dressing. The wear on main rolls depends entirely on the sizes being rolled and unless a mill is able to standardize on its product it is seldom that the same roll wear condition presents itself; nevertheless the tapered middle roll to fit this wear is standard and even though unsatisfactory conditions do exist, and the roller must change his system of draughts often adding extra passes; there is little that can be done. The grinder has the advantage of being able to taper a roll in a short period of an hour or two to meet a special condition of wear. Of course, irregular wear can not be prepared for, but unusual conditions are met and handled in a most satisfactory fashion.

The tandem mill is not a new idea for before Lauth's time the soft mill and finishing mill, of course, could be called tandem. However, the idea of two mills in line is a recent development. The inception of the tandem in line was the result of two demands—First, production, second finish; but finish should be

further subdivided into headings of gauge and surface. The tandem mill has been a success on a specialized type of product, and has justified the ideas of increased production and better finish. It is a question as to the degree of success a well-designed layout on larger mills handling a broader variation in gauges and sizes rolled would experience. All the tandem mills in successful operation, save one, have rolls only 84 inches long and specialize on plates three-sixteenths of an inch thick and lighter down to 14 and 15 gauge. Two 100-inch tandem mills have been operated but only one remains. That evidence may be indicative of its success.

Tandem Mill Possesses Attractive Features.

The tandem mill in principle has some attractive features which are sound and which will in years to come possibly mean a general adoption. No one can deny that the principle of roughing a slab or slab ingot on the same set of rolls with which a high finish is expected is a conflicting process, and the best results can not be obtained. The tandem mill overcomes this. It is true that the roll speed employed in breaking down slabs should not be that employed in the finishing of plates where light draughts are used. The tandem mill has this flexibility; the roughing stand can be operated at the proper roughing speed and the finishing stand speed can be increased. This directly aids production and on the lighter plates finishes hotter material which is very likely to be more satisfactory from the standpoint of gauge variation and appearance.

There seems to be a difference in opinion among the tandem mill builders as to which is the more successful, the two-high or the three-high roughing. Two prominent manufacturers employ two three-high mills and two, the two-high roughing and three-high finishing. The results obtained appear to be about on a par. The increased cost of the two-high reversing drive installation has in all probability been something of a deciding factor here, for there is little advantage in one over the other except perhaps in case of possibilities of these mills going far enough into the jobbing mill business to roll pairs. Pairs can not very well be roughed in a three-high mill with tilting mill tables and the two-high mill in this case presents advantages. In the adaption of the principle to larger mills the two-high roughing has advantages that should be deciding. The roughing of heavy slabs on a tilting table, which must be built strongly but still light enough to work quickly, is, and always will be, a problem in upkeep. The two-high rougher eliminates this and allows a sturdy type of mill table to be employed.

To summarize, the tandem mill has been a step in development, but has not up to the present proven a general benefit to the business. Its successful applications have been on the narrower mills rolling a more or less specialized product, yet the principle is sound and there is every reason to believe that it will have a widespread adoption on the wider plate mills in years to come.

Painting, Stamping and Furnishing.

There has been very little development in the laying out of sizes on the plate, and the painting, stamping and other finishing requirements. The bulk of the sizing of plates is still done by templet, and the brush and the paint pot, along with the steel stamp and hand hammer are extensively used. Attempts have been made to economize by not using the templet,

which is a costly method, but unsatisfactory results have maintained this method as the most reliable. One well-known manufacturer has installed a machine for the laying out of plates. This machine works on a carriage supported on slides on the opposite side of the marking table. It has a series of cross screw-shafts, with crayon holders running on them operated by electric motors geared to the carriage and connected to dials, which can be set for the various dimensions to be marked. This machine, we understand, is accurate and is handled quite easily and relieves several men. This may be the start of development along this line, but it still is quite inflexible and too slow for mills producing plates at a high rate per hour. The idea is substantial and it would be natural to deduce that good results would evolve.

Painting and stamping present a difficult problem to improve on in method and no report of progress can be recorded here.

Shearing Presents Problems.

The shearing end of a plate mill has always presented a problem to the operator. In this part of the plate mill, many men are used and little mechanical apparatus has been introduced that is able to materially cut the number of men employed and at the same time maintain the standard of quality. The generally accepted layout for shearing is the location of the end shears at the end of the runout following the cooling and marking beds. The end shears deliver onto a caster bed of three or four times the width of the runout table, at the edges of which are the side shears, staggered so that it is possible to work on both shears simultaneously without the plates conflicting. This requires a crew to each side shear, a number of men to push from the end shear to the side shear and from one side shear to the other, plus the regular quota of scrap men. A few improvements on this method have been developed but they have not been convincing to the majority of plate makers and the caster bed and push gangs are still employed.

The multiple rotary side trimming shear has been put into practice by some manufacturers. This machine trims both sides simultaneously and requires about the same number of men that are employed on one gate shear. The push gangs are also eliminated. Of course, this machine is only able to shear rectangular plate and auxiliary shearing equipment has to be maintained and manned to take care of sketches and plates that are not standard, but the auxiliary shearing equipment can be worked only a fractional part of the time and in this way labor costs can be lessened and a primitive process abandoned. On the face of the facts it appears that there has been development, but here again we find that the rotary trimming shear has only solved the problem in the production of lighter gauges and results on the heavier gauges have not produced a cut comparable to that obtained on a well-lined gate shear; and so again we find a specialized development, but with possibilities of mechanical improvement to take in all gauges.

The Ennis Shearing Table.

The most recent promising appearing shearing development is the Ennis table, invented by Mr. L. Ennis, of Dorman Long & Company, in England. His patent is a table which appears much like a section of the ordinary roller table, but mounted on wheels and operated on rails. The plate, after being end sheared, is delivered onto this table and transferred

to the side shears. Here by means of a double series of live rolls divided in the middle, capable of independent operation, so that they may be operated in unison and in the same direction of rotation, or so that those on one side of the table may be rotated at a slower speed than those on the opposite side or even in the reverse direction so as to secure a drag or slewing action to the plate, and in this way permit the operator to bring the plate on the table into position for shearing. In addition to the rollers there is a series of electromagnets, capable of being traversed across the table so as to hold the plate at any desired point. The faces of the magnets are just below the level of the top of the rolls and each magnet can be made free to revolve in its own bearings and be caused to act independently of the other magnets. This machine or method is being used generally in all recent shearing arrangements in English plate mills, and has been employed in principle by one American manufacturer. It is the first radical departure from the old method which still enables the producer to benefit by the cut of the gate type of side shears. From reports, present installations could not take care of the production of the average plate mill in the United States, but the principle is successful in eliminating labor, for it can be handled with one man to operate the table, one shear man and two scrap men to each shear.

The Multiple Side Trimming Shear.

Another American manufacturer has started to develop the multiple side trimming shear, using the gate shear instead of the rotary. This is still in the experimental stage but fundamentally is of sound principle and should evolve into something worth while in the direction of better quality and greater economy.

Types of shears, like mills, have not changed appreciably. The electric shear has replaced the hydraulic in many places, but many operators do not feel that this has been an improvement. It has probably been the result of the widespread application of electricity to all rolling mill auxiliary machinery, and the decreasing amount of hydraulic power used. The ability of the hydraulic shear to operate at variable speeds and to make fractional cuts has been advantageous, and if electric shears are to give the satisfaction obtained by the hydraulic, they must be built to equal their performance.

The finishing ends of the mills are developing other apparatus to save labor—scrap conveyors, roller bearing casters, scrap coiling and handling accessories, and it should not be long before the sight of the overpopulated shear room will be a rare one.

The shearing end is perhaps in more of a transitory period than any other department in the process of plate manufacture and it is only reasonable to assume that the principles which have just acquired a fair start will bring about great progress here.

Developments in Universal Plate Mills.

Before going on to discuss the tendencies of plate manufacture, something should be said about developments in universal plate mills, for until now developments in sheared mills has been the topic. Of the 24,096,231 tons of plate produced since the war 7,562,788 tons have been rolled on universal mills. This, in comparison with the country's universal plate-producing capacity, shows the universal mills to have been more steadily employed than the sheared units.

Unlike the sheared plate mill, there have been some new installations since the war, but these have all specialized in the manufacture of skelp and although these mills must meet a high quality standard, they can not be classified as plate producers. The new universal skelp mills, however, embody recent improvements which would appear alike in universal plate mills producing plate. Probably the most outstanding improvements are the provision for more rapid changes of vertical and horizontal rolls. Vertical roll changes have always meant considerable delay and now, by new types of couplings and new housing design, have been improved upon considerably.

The hand operated adjustable breaker block has gone into the discard; straightening adjustments are now being taken care of by an electrical screw which is operated by the mill screw operator.

Straightening devices are producing better results; the trade no longer accepts the $\frac{1}{8}$ inch in five feet camber allowance for many purposes, and developments along that line are eliminating cambers. Straightening blocks between the mill and the cooling bed are limited by the rate at which the mill turns out plates, which in many cases is too rapid to allow plates to cool sufficiently to stay straight. Developments to straighten further along the line are in order and are being considered. Until adopted, however, production will be held back and costs will be increased by the extra passes required in the mill to produce straight plates.

Planishing Stand Coming Back.

New and stricter surface requirements on universal plates are bringing back the planishing stand. This is by no means new, but was discarded by many universal plate producers as unnecessary, and the plates have been finished on the one stand with the resultant cracked appearing surface. The planishing stand will eliminate this and will increase the production.

The three-high universal mill has not enjoyed the popularity compared with the older two-high mill, that the three-high sheared mill enjoyed over the former two-high. Operators of three-high units have experienced trouble in producing straight long plates, probably due to the difficulty in obtaining stable roll alignment in the three-high units. Slight lateral or crossing movements of the middle roll will tell their tale on a long plate. Three-high universal mills, however, have proved satisfactory for the manufacture of skelp and new universal units to produce that commodity will probably be of the three-high type. The tendency of the producers of universal plates, on the other hand, appears to be in the direction of the two-high mill with a planishing stand, in which a finish will be obtained by three passes or more.

Methods of handling universal plates beyond the mill have changed little. The standard type of lateral cooling bed delivering into the end shear is producing satisfactory results and is economical. If one will produce a square edged plate, true to gauge, and straight with a smooth finish, very little criticism will result. These requirements with the exception of straightness must result from the mill proper and progress is being made there.

Competition Has Lowered Prices.

Today in the plate business we find what can be justifiably called an economic paradox. With the de-

mand for plates greater than at any time in the history of this country, we find the price of this commodity lower than at any time in the last ten years with the exception of 1922, which felt the aftermath of the 1921 deflation when the plate production was only 24 per cent of the country's capacity. It is generally conceded that demand regulates price, but here with greater demand prices have dropped off. This goes to show that despite the great market for this commodity competition has dealt decisive blows which have produced a desirable situation only for the consuming trade. Not only has this competition lowered the price but it has stimulated each producer to the point where he at times accepts business calling for special handling and increased production costs merely to keep from lowering his colors to rival manufacturers, and in this way the customer enjoys a twofold blessing. From this there is only one conclusion to be drawn. The situation must be accepted and the sooner producers are convinced of it and meet the standards, the sooner will new requirements be produced on an economic basis.

In the future the fabricators, tank builders, car shops and all other consumers are not going to expend money to put plates into condition for their uses but will specify the perfect plate, accurate to dimensions, without gauge variations, and delivered to them so that they can be handled through their processes with the minimum of expense. This condition comes as a matter of self-preservation. Competition is just as keen in fields which consume plate as it is in the plate business. Mechanical labor-saving equipment and a low price for raw materials for their work are essential to making any manufacturing business a profitable one. Progressive industrial plate-using concerns are employing as many mechanical operations as possible, and this usually means that plates are handled either in numbers at the same time, which in turn means they must all be alike, or are handled singly by a machine which is not able to alter its operation to fit plates which are a little off in some detail. The consumer is justified in his stand for the perfect plate and it is up to the plate makers to develop means of being certain of producing it.

Tendency Toward Specialization.

The tendency toward specialization is gripping the plate business and the manufacturer who can produce large tonnages of any one type of plate is going to be most successful. An outstanding example is the work being done on the 84-inch tandem plate mill installations, which are doing the work of the jobbing sheet mill, and are showing excellent results. The country's largest mills are specialists too, they do not attempt to operate on the ordinary run of sizes even if they could be made. They cater only to the orders where size and quality extras make it worth while to operate.

The mills attached to steel plants producing many other commodities besides plate are the ones which present-day conditions affect most seriously, for they can not specialize and must operate on a very flexible basis, ready to produce all gauges and sizes, and qualities. These are the mills which must be constantly looking for new developments, for they must be equipped to produce for the most exacting requirements as well as those not so exact. The specializing tendency will always leave this type of mill out and these operators must necessarily always be progressive enough to adopt any development that means advantage in producing cost.

Use of Slab Increasing.

Before leaving the topic of specialization, we should speak of the increasing use of the slab and the decreasing use of the slab ingot. When considering the plate produced from the slab or slab ingot there is much to be said on both sides which could cause us to digress into the manufacture of steel and methods of pouring it. However, we will not go farther than to say that the plate mill is not constructed to do the work of a slabbing mill and that the breaking down of thick ingots can not help but be exceedingly more costly on a plate mill, to say nothing of the ill effects that the plate mill experiences. Progress calls for mills specializing and the rolling of slab ingots into plate is in violation to this. Therefore, it is reasonable to assume that the tendency will be to produce plates from slabs and not from slab ingots.

Automotive Trade Requires Minimum Gauge Variation.

The tendency of the automotive trade, as well as other industries which have drawing and pressing operations in their process, is to require a minimum of gauge variation from side to center of the individual plate. This will require changes in the design of mills. Variation from side to center of the individual plate is caused by wearing of the rolls and bending of the rolls, the latter generally known as mill spring. Design can not alter roll wear, but it can stop roll spring. This can be done by using rolls larger in diameter, which is generally considered not desirable from a rolling standpoint, or by supporting or backing up the rolls, which come in contact with the hot steel, by rolls larger in diameter and usually made of steel. This prevents the chill rolls from bending, just as the main rolls of a three-high mill prevent the middle roll from bending. This principle has already been used successfully and the tendency now is toward an increasing popularity. Although we have not as yet heard of a five-high plate mill, it certainly is not beyond speculation. Present ideas along these lines appear in the way of a tandem layout with the four-high finishing composed of chilled iron rolls backed up by steel. The process used will be standard tandem practice of roughing the slab down to a thickness where three or more passes in the finishing stand will be sufficient to take the thicker center out of the plate and produce a perfect surface.

Shearing tendencies are incorporating closer tolerances. More particular edges, accurate dimensions, and no shear bows, all these will call for colder shearing, and perhaps resquaring and extensions to cooling beds to prevent the necessity of rehandling. Rehandling of material, however, appears to be a feasible future and, if this be so, the best move is to look to the business which have been handling the product of plate mills for years, the car shops, boiler shops and fabricators, and take advantage of all the experience they have had and advancement they have made in equipment for economical handling of plate.

The tendency is plainly to meet the exact demands of the customer. The production of plate will probably not become less competitive and by this reasoning the sooner the plate manufacturers accept this to be the situation, the sooner will improvements be made and economies result. This will enable the operators to breathe more freely, knowing that they can face the trade without excuse and with an acceptable product.

Development of Open-Hearth Design

Development of the Open Hearth from Inception and Various Types of Regenerative Steel Melting Furnaces Reviewed —Principles and Operation Briefly Covered

By CHARLES LONGENECKER

THE development of the open hearth process, from its inception to the present, bears tribute to the achievements of many eminent engineers and metallurgists. Like other inventions of a similar nature the advancement of the process called for contributions from various branches of scientific research with the result that the names of the ablest men of science are found in its history. Faraday's last paper, presented before the Royal Institution, was a description of the operation of Siemens' furnace with regenerator's; Le Chatelier suggested various modifications, especially the use of bauxite as a lining for the hearth; Sir Lowthian Bell, Gilchrist, Thomas and Martin were others who through labor and advice, materially assisted in transforming the process from one of questionable value to an assured success. In later years the names of Wellman, Lash, Talbot, Campbell, Bertrand and Monell came into prominence through their activities in connection with various phases of the process.

Long before the open hearth furnace became a reality, steel had been manufactured, in comparative small quantities, on hearths of several types, in crucibles, and in the Bessemer converter, so that the metallurgical features, in connection with steel manufacture were well known. Josiah Marshall Heath in 1839, and Reaumur at a previous date, had been granted patents, whose specifications clearly describe, the production of steel by the melting together of pig metal both with malleable iron (scrap) and with ore. Thus while there had been developments in the metallurgical field, which made possible the production of steel on a large scale, there had been no inventions in the art of heat generation, and its utilization, by which these developments could be made available for quantity output. The invention of the regenerative furnace by Frederick Siemens in 1856 met this want.

Siemens Credited with Regenerative Furnace.

There will always be some doubt as to whom honor is due for the conception of the principle of regeneration but there is no doubt as to whom credit must be given for its reduction to practical operation. This credit assuredly goes to Frederick Siemens as it was his invention that really presented a practical method of applying the regenerative principle. Others previously had the conception but none made any marked progress in its application. Undoubtedly Frederick Siemens received very material assistance from his brother William, in the actual construction and operation of the furnace embodying the principle. In fact most of the historical information now available, on the process, emanated from William Siemens and it would appear that it was he who actually carried out the ideas of his brother. Without the regenerative furnace the open hearth process never would have dominated the steel industry as it does today.

A treatment of this subject, as a whole, can best be given under two headings: The furnace in its entirety

and the metallurgical features. The former will be emphasized in this discussion.

First Regenerative Furnace Erected in 1861.

Siemens' first regenerative furnace other than those for experimental purposes was erected in 1861, in Birmingham, and was employed for the melting of glass. In this furnace, 16 to 17 tons of coal was burned per week in comparison with a consumption of 35 tons in the furnace displaced. Other furnaces, of the regenerative type, were then built for the heating of steel, to be rolled. In the earlier furnaces raw coal was burned on a grate placed at one end of the hearth and the gases, distilled from this coal, were burned by the air which had been heated in passing through the regenerator. This form of furnace was not very successful as it was exceedingly difficult to control the temperature on the hearth but it did prove conclusively that by means of the regenerator it was possible to preheat the air to a higher temperature than by any other means then extant. It was also apparent that a gaseous fuel could be passed through the regenerators and, when heated, would admit of very close temperature control as it burned with air, likewise highly heated. Thus, not only was control assured, but the ability to obtain a higher flame temperature, than had ever been secured, was of inestimable value as it made possible the success of the process. The next step therefore was to devise means whereby a reliable and uniform supply of gas could be secured. This was accomplished by the installation of "Gas Producers." Originally these were built integral with the furnace but it was soon evident that such a construction did not allow the flexibility that was desired hence the producers were placed at some distance from the furnace and were connected thereto by a long flue as shown in Fig. 1.

The gases, from the producers, entered this flue at (A), at a temperature of from 600 deg. to 800 deg. F. and, after ascending 20 ft., passed into the horizontal section. In this they were cooled to a temperature of about 225 deg. F. This reduction in temperature increased the density of the gases, so that when they reached the vertical section (B) their weight was greatly augmented. Thus the descending column of gases, being heavier than the ascending column, caused a pressure towards the furnace and insured a continuous flow of gas. The loss of heat was not detrimental as there is no gain in having the gas enter the regenerator at a temperature higher than that of the products of combustion leaving it.

Open Hearth Steel Made in 1869.

History records the initial casting of steel, from an open hearth furnace, installed as permanent equipment in the year 1869 at the works of the Landore-Siemens Steel Company, near Swansea, Wales. There is no doubt that previous to this time the process had been in operation on an experimental basis for Siemens states (Jeans "History of Steel") that "Mr.

Ramsbottom, engineer in charge of the Crewe Works, of the London and Northwestern Railway, was in 1868 the first to adopt, at these works, the regenerative furnace for the production of steel by the fusion of pig metal and scrap upon the open hearth."

Pierre and Martin Experimented with Open Hearth.

Besides Siemens, Pierre and Emile Martin carried on extensive experiments at Sireuil, France, but the furnace erected at Swansea was the first to really establish the process as is attested by Siemens in his remarks before the Iron and Steel Institute of England in 1869. He reported: "I have established works at Swansea where steel is made in large quantities on the open hearth and there we use 55 tons of small coal per week, producing 73 tons of cast steel ingots, and

formed of silica sand as the basic materials which had been tried and found inferior in binding qualities. Ganister rock, finely crushed, gave the most satisfactory results. The sand at the works of the Messrs. Martin analyzed:

Silica	85.84
Alumina	6.00
Peroxide of iron	3.54
Lime	0.33
Magnesia	0.42
Water	4.06

Fig. 2 illustrates the design of the furnaces at Sireuil and, as it was constructed from sketches furnished by Siemens it is typical of the furnaces of that period. Except in general outline the design is vastly different to that of the modern furnace, but from it,

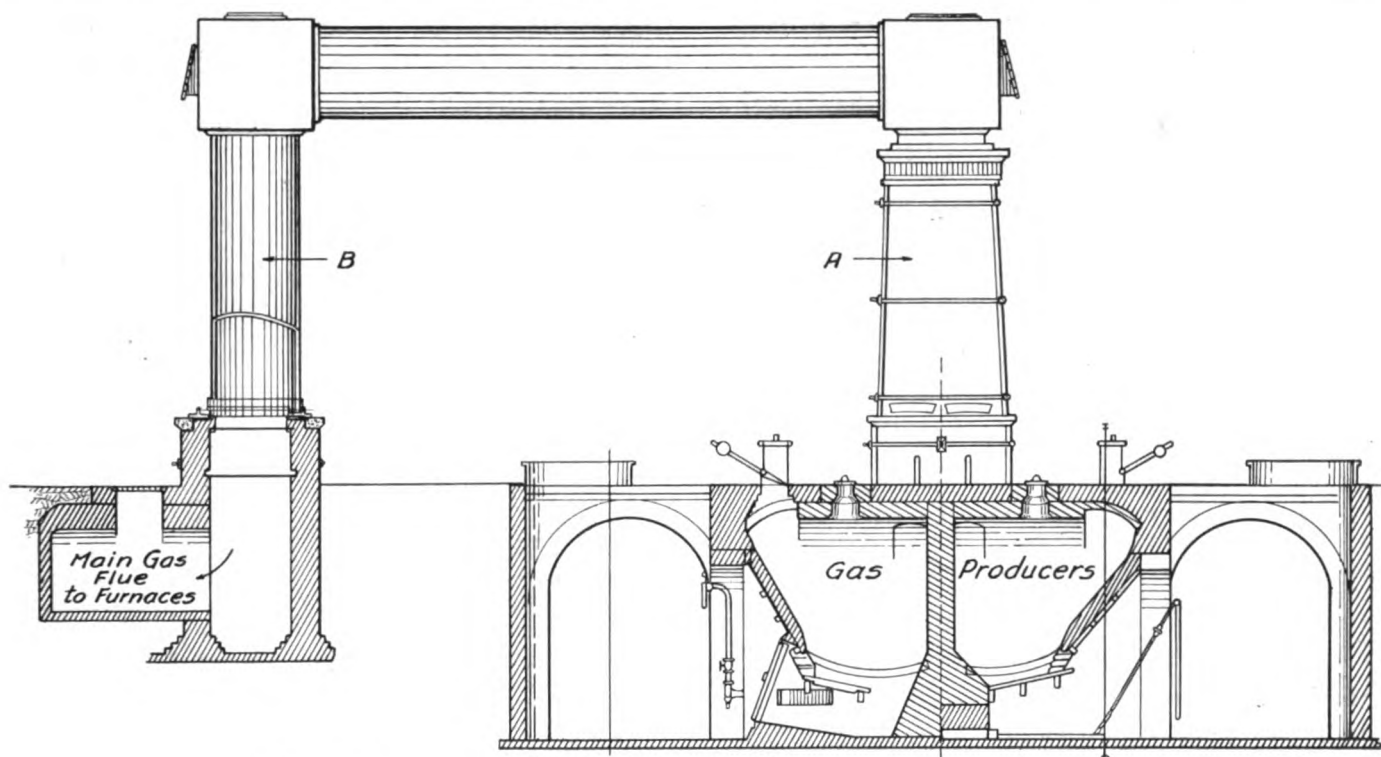


FIG. 1—Flue connecting gas producers and furnace designed to assist flow of gas.

working, at the same time, two puddling furnaces. Taking for the puddling furnaces 18 tons, there remains 37 tons of coal consumed for melting 73 tons of steel. This represents therefore, a consumption of less than 10 cwts (1120 lbs.) of small coal to make one ton of steel."

At Swansea the pig and ore process was used exclusively while at Sireuil the pig and scrap, or Siemens-Martin, process was preferred.

Many Difficulties Experienced with Early Furnaces.

Difficulties of various kinds attended the operation of these early furnaces, at Sireuil, where the Martin brothers had erected furnaces, trouble was experienced in maintaining the roof and in keeping the bottom in repair. The roof was originally constructed of Dianas brick, but these melted so rapidly that they were replaced by brick made of crushed pure quartz rock to which 2 per cent of quicklime was added as a binding agent. These brick gave very satisfactory service and are similar to those found in furnaces of the present day. The bottoms of the furnaces were

by frequent alterations, has been evolved the furnace of today.

The change in this furnace and the yield obtained averaged:

Initial charge of pig iron	3,562 lbs.
Wrought iron—successfully added	4,346 lbs.
Steel scrap—successfully added	4,044 lbs.
Final addition of spiegeleisen	1,086 lbs.
Total weight of charge	13,038 lbs.
Yield in ingots	12,118 lbs.
Scrap	438
Loss	482

Thomas and Gilchrist First to Use Basic Lining.

Before the open hearth process was recognized as a permanent institution Bessemer had been making steel, for some years, in his converter. He lined the vessel with sand, the same as did Martin his furnace bottom, but after some years of operation it became apparent that a silicious lining imposed limitations of a metallurgical nature. Experiments, previously conducted, had proved the practicability of removing phosphorus from molten metal by the addition to

the metal, bases consisting mainly of lime. It was impossible to make such additions in any melting chamber with an acid, or silicious lining, as such a lining would be destroyed by the basic slag formed on the fluid metal. The only alternative then was to use as a lining some basic substance which would remain unaffected when in contact with a slag of like composition. Such a procedure had been given consideration and trial, by several scientists, but it remained for Sidney Gilchrist Thomas, and his cousin, Percy I. Gilchrist to demonstrate its feasibility in practice. They lined a converter with crushed magnes. um limestone to which had been added silicate of soda. Limestone itself was added to the charge. Under these conditions they were able to practically eliminate phosphorus from metal originally containing a high percentage. The actual reduction was from a pig containing 1.30 per cent of phosphorus to steel with a content of .09 per cent.

It was some years before the basic process, as it is now known, became firmly established. In the United States, the Otis Steel Company was the first to make steel on a basic bottom. This was in 1886.

Lack of Durable Lining Delays Development.

In tracing the development of the open hearth process it is interesting to observe the "practice" followed. Thus the fuel consumed, per ton of metal produced at Swansea, was 1,120 lbs. while it required eight to nine hours to complete a heat of five to seven tons. There was much trouble with the linings which were not durable and it was this feature that delayed the extensive adoption of the basic process. Also the output from basic lined furnaces was too small. To protect the linings at the slag line, Siemens reported the installation of steel blocks which "were exposed to the cooling influence of the atmosphere on one side and he was rather inclined to the opinion that by this arrangement the elimination of phosphorus might be carried out in the open hearth process without resorting to a basic lining."

"Slag Pockets" Introduced.

Improvements in furnace operation and design were being made continually. The port construction had been improved and the velocity of the gases, in passing over the bath, was increased. These gases

carried in suspension quantities of fine dust, slag, etc., and in passing through the regenerators the minute particles were deposited on the checker brick. To prevent this action "slag pockets" were placed directly under the downtakes and the regenerators were moved to the ends of the furnaces.

A still more radical change was made with the invention of the Bathe type of open hearth furnace. This furnace had inherent faults which prevented its wide adoption, but it did serve to emphasize the necessity for the removal of the regenerators from under the furnace. Mr. Dick in presenting a description of this furnace to the Iron and Steel Institution of England in 1884 stated: "The regenerators not being under the furnace are out of harm's way in event of a "break-out" and, "they have nothing but their own weight to carry as the furnace is not supported in any way by the regenerators, for a worse support than a mass of white-hot brickwork, on which to carry the weight of a furnace and its load of metal, can scarcely be conceived." Another trouble experienced with regenerators placed under the furnace proper was the leakage of gas and air through the common wall.

Furnace Volume Increased for Flame Development.

About this same time, it became evident to furnace operators that better results could be obtained by allowing greater volume for flame development. The roofs on the early furnaces had been designed with the idea of forcing, and holding the flame on the surface of the bath. To secure this the roofs had been depressed as shown in Fig. 2. A change was now made and the roof was either straight or, in some cases even slightly arched. At this same time the port construction was altered so as to admit the air over the gas, but it was not given the slope found in modern furnaces. Engineers did appreciate though the advisability of keeping the flame from coming in contact with the roof and side walls. They also became aware of the beneficial results to be secured when the full radiant effect of the flame was utilized. It required only a just appreciation of the value of these features to assure their employment.

Pernot Revolving Hearth Furnace.

A development which is of historical interest only was that of the Pernot furnace. This furnace was the first to employ a revolving hearth for the manufacture

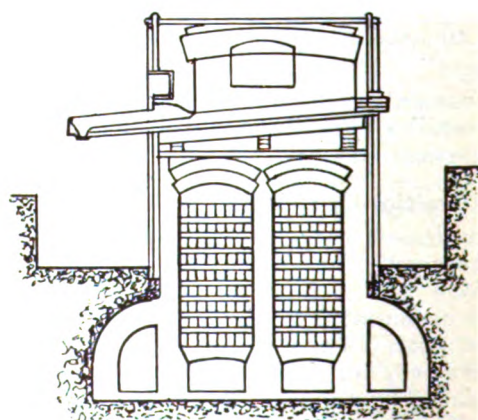
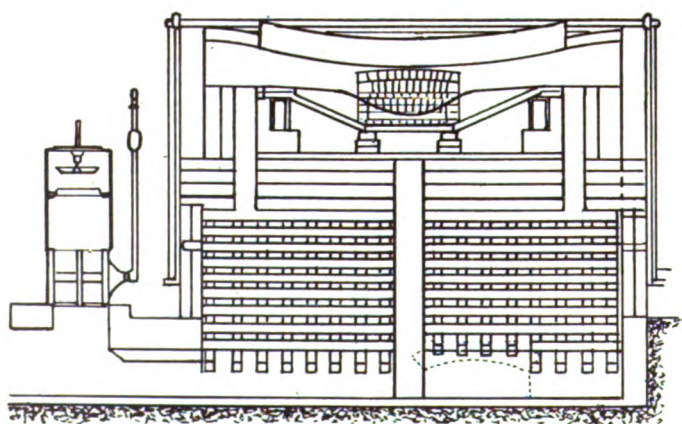


FIG. 2—Cross section of the furnaces at Sireuil.

of steel. The inventors claimed they could produce wrought iron on steel as desired and while it was successful, to a degree, it never received extended recognition. The hearth of the furnace which was round, was supported on a shaft inclined 6 deg. from the vertical so that it sloped from the charging door towards the "tap hole." Ports and regenerators were of the Siemens type as used at their time, 1874. In operation, the revolving of the hearth tended to agitate the metal and assure a thorough mixing and rapid action between the various constituents. The conception, while ingenious, was too complicated and the furnace was discarded due to high maintenance cost and trouble in service.

First Open Hearth Erected in U. S. in 1868.

The first furnace erected in the United States was at the plant of Cooper, Hewitt & Company in Trenton, N. J. This was in 1868. It did not prove a success and was abandoned a few years later. Another was built at The Bay State Iron Works, of South Boston in 1869. This furnace has the honor of being the first to establish the industry in this country. It was of five tons capacity and resembled in design contemporary furnaces then operating in England. The first steel was made from puddle bar and English hematite pig.

About 1889, H. H. Campbell, of the Pennsylvania Steel Company, Steelton, Pa., erected the first tilting furnace. This furnace differed materially from any

type of furnace heretofore operated. In transverse cross-section the furnace was elliptical. It revolved about its longitudinal axis, which coincided with a line passing through the center line of the ports, and hence when the furnace was tilted the flow of gas could be maintained uninterrupted. It was claimed for this type of furnace that very little attention need be given the tap-hole; that the bottom can be kept in better repair, as compared with stationary furnaces; that repairs to the front and back walls are easily made; that slag can be run-off at any time; and that any quantity of metal can be tapped when desired.

The Wellman Tilting Furnace.

The Wellman tilting furnace followed that of Campbell's. It was very similar to Campbell's furnace except in the manner of tilting. Furnaces of the Campbell and Wellman type have been employed more for special purposes than in general practice.

Several furnaces have been designed and placed in operation, in which the regenerators have been located above the bath, but none of these ever survived for any period of time. Of this design were the Radcliffe and Thwaite furnaces.

A survey of the changes that have been made in the design of the open hearth furnace, from time to time, can not fail to impress one with the great divergence in judgment among engineers as to what constitutes the best construction.

Wire Galvanizing Methods Discussed

Process of Wire Galvanizing and the Equipment Used Is Treated
in a Non-technical Manner—Directions for Dross-
ing and Dross Sweating Given

By CLEMENT F. POPPLETON*

THE most important galvanized product, commercially speaking, is sheets, which the writer has already dealt with exhaustively in other published articles. The next important galvanized product from a commercial standpoint is wire. Before proceeding to describe and illustrate the galvanizing of wire it will perhaps be well to give some data on the conditions which must be met and overcome to galvanize any product.

The first step, and most essential is to thoroughly clean the article to be galvanized. This is accomplished, usually by the process known as "pickling" which consists of immersing the article in a bath of acid. If sulphuric acid is used exclusively the solution may vary from 4 to 10 per cent by weight, of commercial acid, the usual range being about midway between the extremes. To give the best results the solution should be heated, this is usually accomplished by introducing live steam into the pickle tanks.

Pickling.

Articles may be pickled by simple immersion, but this is very uncertain and consequently the articles are usually agitated in the solution, either by hand or mechanically. Where the article is of such a nature as to permit of mechanical manipulation that method

is preferred, as it is regular in action and each article may be so handled as to receive an equal amount of movement in the acid solution, thus preventing over-pickling. As to the correct acid strength, a solution of 7½ per cent sulphuric acid in water maintained at a temperature of 150 deg. F. is probably the best.

After pickling, the articles must be introduced into the bath of molten spelter through a flux. The object of this flux is to give a final chemical cleaning to the article and remove any oxide that may have formed on the article after leaving the pickle tank. A good flux for general utility is composed of 4 lbs. of gray granulated sal ammoniac, 2 oz. of glycerine, and 2 oz. of tallow.

The next essential for good work is that the article shall remain in the spelter bath long enough for its temperature to become equal with that of the molten spelter. If it does not become heated sufficiently it will be unevenly coated and if too cool will not be coated at all in spots while having a very heavy coating in others. On the other hand if allowed to remain too long in the spelter bath it will greatly reduce the output. Thus it will be seen that for all articles, such as wire, sheets, etc., which are passed mechanically through the molten spelter some means must be provided to vary the speed of the feed.

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Galvanizing Wire.

Wire, wire cloth and poultry netting are galvanized practically automatically. In this class of work it is necessary to divide the molten metal longitudinally with a flux guard consisting of an angle bar to which is attached a sheet of about 16-gauge steel extending downward below the line of the molten spelter for about 3 inches. Immediately in front of the flux guard is the flux box filled with a very heavy flux of sal ammoniac made up as previously described. This flux must always be kept fresh by dipping out the spent flux and spreading it on the center portion of the bath between the flux box and coke retaining bar. The poultry netting, or wire cloth is fed into the flux box between rollers, and held in the bath by two rollers spaced about 2 feet apart, suspended from a frame. The netting or cloth is passed under these rollers and then led to the exit side of the bath where a revolving drum is arranged to receive the netting after it is galvanized.

Between the central portion of the bath and the exit is arranged another flux guard and the space between this guard and the end of the bath is filled with fine coke dust to a depth of at least 4 inch. The coke dust must be constantly sprinkled with water while the material is passing through. The best way to accomplish this is by means of a perforated pipe of requisite size discharging water constantly in sufficient amount to keep the coke dust on the surface of the metal thoroughly moistened.

Galvanizing Equipment.

The revolving receiving drum already mentioned is so arranged that the speed may be varied to suit different weights and gauges of material. It is demountable so that the product may be easily removed when the predetermined length of roll has been run through the bath. When wire is being galvanized, several strands are passed through simultaneously and the speed varies with the gauge of the wire. Fig. 1 shows an improved automatic device for galvanizing wire. The illustration shows a longitudinal cross section of the entire apparatus, which is arranged to handle the black wire as received from the wire mill, including pickling, galvanizing and coiling.

The wire to be galvanized is placed on racks at the rear of the sulphuric acid pickling vat, No. 1. It is drawn through this vat by a coiling spool placed at a

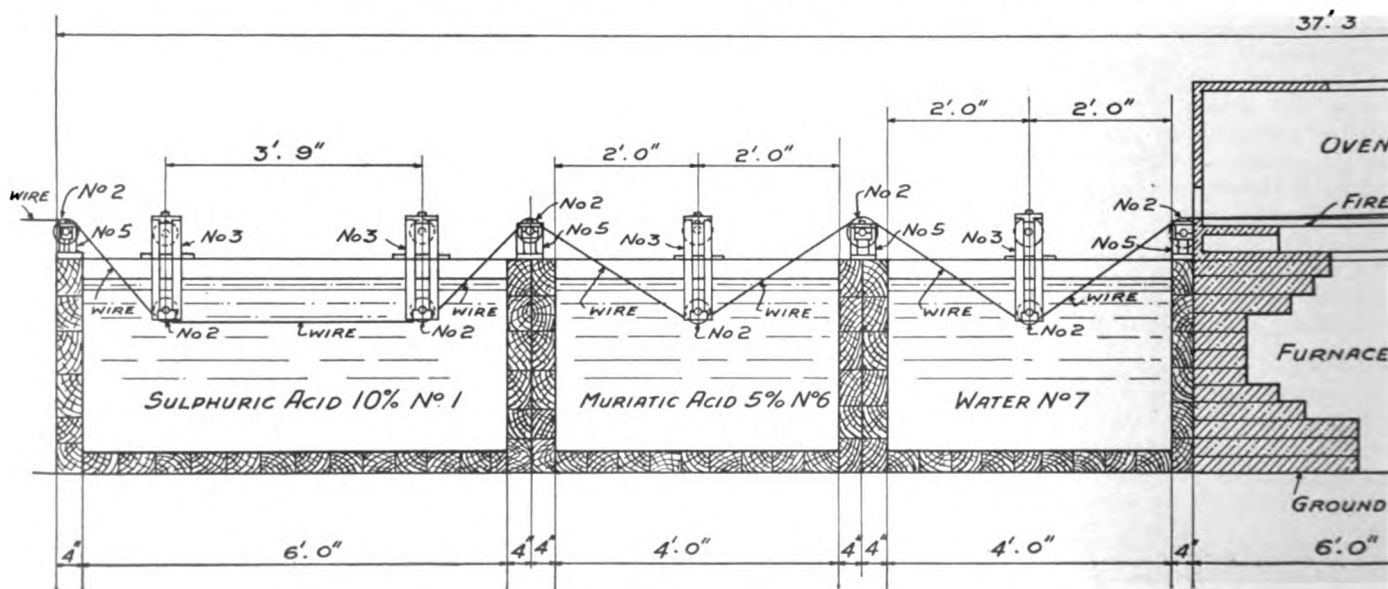
suitable distance beyond the wiping brushes, No. 12. A series of porcelain or glass rollers, No. 2, mounted loosely on a shaft which in turn is mounted on brackets, No. 3, are used to carry the wires through the various vats. These brackets project above the acid bath and the shaft, bearings and rollers are slideable in the brackets. By this arrangement the strands of wire can be threaded in a horizontal straight line without having to touch the acid. The brackets supporting the shafts, bearings and rollers are then forced under the acid and wedged into the working position. As the rollers are mounted independently, one wire, in case of a breakage, can be fixed independently without stopping the balance of the apparatus. These shafts and bearings are of acid proof metal, while the rollers as already mentioned are of either glass or porcelain. Rollers are also provided on partitions between the vats to carry the wires.

After passing through the sulphuric acid pickling bath, the wires are led over another series of rollers and brackets into the muriatic acid pickling vat, No. 6, and then into the washing bath, No. 7. The washing bath must be kept fresh by a constant supply of running water. While the rollers in the water bath need not necessarily be of acid proof metal, they are usually duplicates of those used in the other vats so as to permit interchanging.

The Drying Oven.

From the washing bath the wires pass into the drying oven, No. 8, which consists of a cast iron box filled with grate bars to retain the heat. Its function is to drive off the entrained hydrogen from the outer surface of the wires. This oven is mounted on the top of furnace, No. 9, built of fire brick and fired with either coke, coal, or gas. Of the three fuels, coke is to be preferred as the galvanizing bath is usually heated with that fuel.

The next step in the process is the actual galvanizing. The spelter bath, No. 10, is arranged in line with the oven and the wires pass through the spelter under and over rollers and brackets in the same manner as they pass through the acid baths. After being galvanized, the wires pass through two sets of dies, Nos. 11 and 12, set to grip the wires on opposite quadrants and are adjustable for various gauges. The final wiping through asbestos brushes removes all surplus spelter and leaves the product with a fine finish. Pass-



ing the wire through the two sets of dies while the wire and spelter are still hot drives the coating into the steel or iron, reduces thickness of coating, and gives the coating much greater adhesion to the base, making a better product as the coating is so firmly attached to the base that it can be bent and worked without the danger of peeling. The wires are then wound on spools driven by motor or other suitable power, and so arranged that one or more spools may be removed independently. This entire apparatus occupies a floor space of about 38 ft. x 6 ft. independent of the black and galvanized wire spools.

Effect of Hydrogen in Galvanizing.

A feature generally little understood, and which hitherto has not received the attention it merits, is the action of hydrogen in its relation to the spelter coating of wire or sheets of either iron or steel. The following quotation from G. A. White's book entitled, "A Metallurgical Study of the Steel Base as Related to Galvanizing," throws considerable light on the subject.

"In the pickling process moisture or hydrogen, as well as the arsenic in the acid, may also produce these results (rough and heavy coating on wire or small granular spangles on sheets). It is generally known that hydrogen can largely be removed from iron by soaking it in water. A number of sheets were soaked in water for a week and then taken out and galvanized, the result was large spangles (i.e., light coating). It is therefore apparent that the hydrogen taken up by the sheets in the pickling operation is largely responsible for the small spangles on sheets and the corresponding condition in wire. Another experiment was made, galvanized sheets were pickled to remove the spelter coating and the hydrogen gas was afterwards driven off by heating the sheets to a temperature of about 800 deg. F. When galvanized after this treatment the resulting spangles were large." The foregoing is the reason for the inclusion of the drying oven in the apparatus just described. In the apparatus under description, from 18 to 30 wires may be galvanized at the same time.

Buildings Should Be Well Ventilated.

All buildings in which galvanizing operations are carried on should be of ample height and well ventilated. As the fumes from the acid tanks and the spelter bath do not readily escape, some means must

be provided for their removal. A good ventilator should be installed in the roof, and moveable hoods should be provided over the acid tanks and galvanizing kettle. The hoods over the acid tanks need not be movable, but one over the spelter bath must be to allow free access to the kettle for the purpose of dressing, whether moveable or fixed the hoods should be rectangular in form and sufficiently large at the bottom to extend out over the tanks and kettle. The hoods on all sides should slope toward the top at an angle of about 30 deg. and connect with a suitable pipe provided with an exhaust fan of ample size. If this is thoroughly done the working conditions will be fairly comfortable. Hoods should be arranged as low as possible over the tanks and kettle so as not to interfere with the workmen. When hoods are arranged over large tanks or kettles, they should be mounted on a trolley or an overhead track to allow of easy manipulation for dressing.

All buildings used for galvanizing purposes should be of brick, stone or concrete, and the roof trusses should be of timber, preferably yellow pine, covered with slate or tile, as metal of a ferrous nature corrodes rapidly if exposed to acid or spelter fumes.

Disposal of Spent Liquors.

Considerable water is used in the process of galvanizing and provision must be made for proper drainage. The best plan is to provide catch basins under the various acid and water tanks and connect these by means of tile pipe to the sewer. Too much stress can not be laid on having all conductors connected with the process of galvanizing, whether for spent acid, water or fumes, of ample size. In the layout of a galvanizing plant some method must be arranged to deal with the spent acid within the plant itself, as nearly all municipalities prohibit the discharge of acid into the municipal sewer system. If the quantity to be disposed of is large, it pays to install an acid recovery plant. At John Sommers Sons, Ltd., Chester, England, such a plant was installed and proved to be a highly remunerative investment. The oxide of iron recovered (used as a pigment in paint making) more than paid for the cost of operation and interest on the investment, and left the recovered acid as clear profit.

For the purpose of heating the acid and water tanks, a supply of live steam must be provided, and as this is of low pressure, exhaust steam may be used

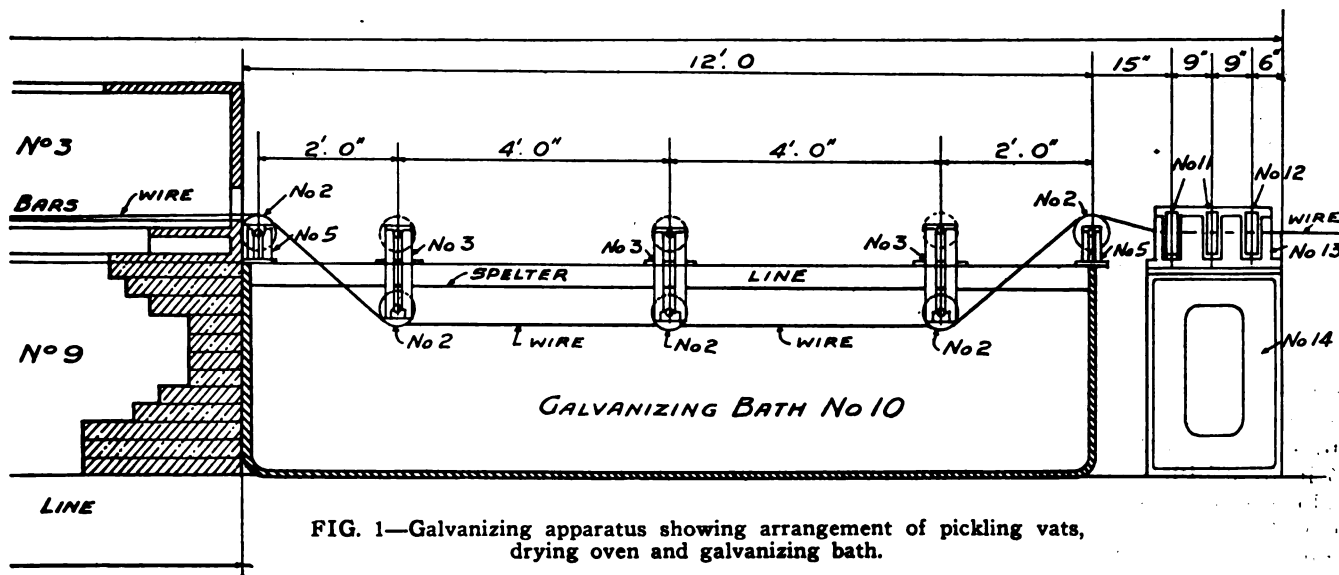


FIG. 1—Galvanizing apparatus showing arrangement of pickling vats, drying oven and galvanizing bath.

if available, but this is seldom the case in modern plants which as a rule are motor driven.

The Galvanizing Kettle.

It is well known that all of the common metals are soluble in molten zinc, and with the exception of lead and pure iron are miscible in all proportions. Old galvanizers used iron exclusively, but with the introduction of Bessemer and open-hearth steel; manufacturers of galvanizing equipment usually use steel because it possesses certain very distinct advantages over wrought iron. It does however go into solution much

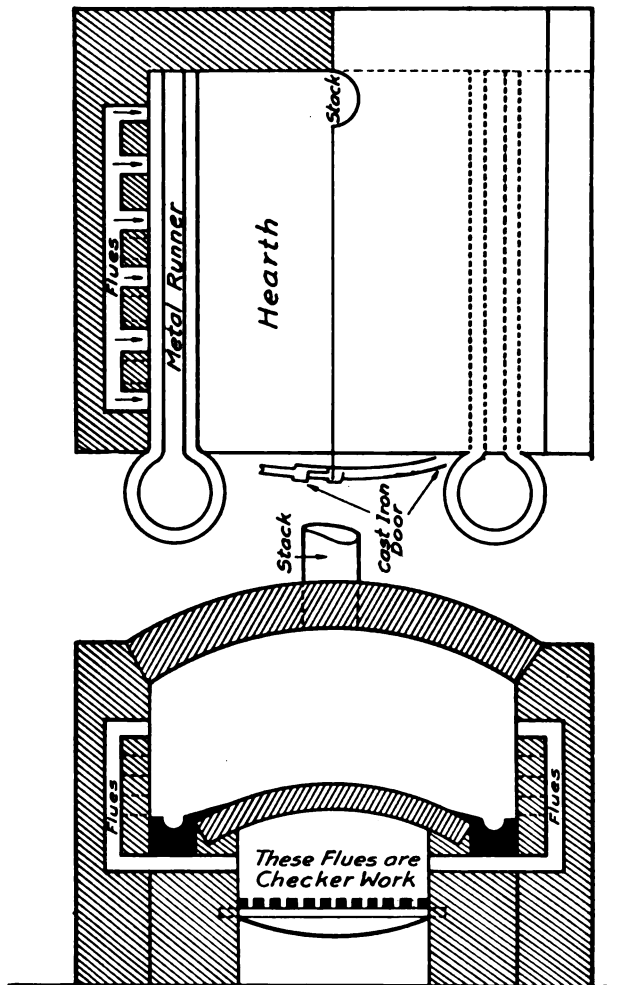


FIG. 2—Plan and sectional view of sweating furnace.

faster than did the old wrought iron and for the last 20 years there has been a constant search for a material which will work as well as steel and at the same time resist the action of the spelter as well as the iron.

In bricking in a galvanizing kettle, grates may or may not be used, the writer, however, prefers not to use grates. A fuel space of about 11 inch at the bottom tapered to 9 inch at the top is all that is necessary for ordinary purposes. The kettles may be heated with soft coal, coke, fuel oil or natural gas, but the best fuel is gas-house coke. Cleaning holes about a brick wide (9 inch) and three bricks high, should be provided at floor level. Midway between the top and bottom of the setting, draft holes half a brick wide ($4\frac{1}{2}$ inch) and three bricks high are required. These are closed by means of a casting which is moveable to regulate the amount of draft. When not in use for cleaning out purposes the bottom holes may be stopped

with loose bricks. The top is covered with cast iron plates about $1\frac{1}{4}$ inch thick with a lip about $4\frac{1}{2}$ inch extending down over the brickwork to act as a binder. First quality highly refractory fire brick should be used for the setting.

Dross.

This substance, which forms in the process of galvanizing, is composed of particles of iron or steel, in a fine state of sub-division, and more or less burnt spelter. When in operation the molten spelter is stratified. At the bottom of the kettle is a layer of lead, sometimes purposely added to afford a cushion for the superimposed layer of dross, while in other cases the galvanizer depends upon the lead content of the spelter to provide this cushion. Next to the strata of lead is a layer of dross, and above that the more or less pure zinc. This stratification results from the different specific gravities of the metals. Dross has a specific gravity between that of a spelter and steel which is nearly 50 per cent greater than that of pure zinc. The melting point of pure zinc is 787 deg. F. while that of commercial spelter used in galvanizing is about 750 deg. F. For galvanizing wire the temperature should be from 900 to 950 deg. F., as any increase above this point is injurious and results in excessive oxidation of the spelter and formation of dross.

Any temperature above 1000 deg. F., which is the critical temperature of commercial spelter, will burn the metal and form dross, hence the galvanizers expression, "dross makes dross." A high temperature, in addition to making an excess of dross, also is the cause of excessive zinc oxide, a greater source of loss comparatively than dross, because an unequal quantity of oxide is formed. The monetary loss is greater because of the relatively low price which is obtainable for oxide, "zinc ashes," as it is known, as compared to dross.

Spelter Temperature Must Be Carefully Controlled.

"Zinc ashes," after refining, is used as a pigment in paint making, but as it is very impure and stained with sal ammoniac it can not be used for white zinc paint. This operation of drossing is very important and is performed as follows: The sal ammoniac flux is first skimmed from the top of the kettle with a dipper of thin perforated sheet iron of a suitable shape. For the sake of economy it is advisable to run the hot spent flux into shallow sheet iron pans to be broken up when cold and returned to the top of the kettle after drossing is completed. The small globules of spelter which are entrained in the spent flux are thus, also, returned to the galvanizing bath. After the spent flux has been removed, the actual operation of removing the dross is performed.

The drossing shovel or scoop is made of about $\frac{1}{2}$ -inch steel plate shaped like a shovel with relatively high back and sides, tapered off toward the entering edge, the bottom, sides and back being perforated with $\frac{1}{2}$ -inch holes fairly close together. When using this implement it is forced gently and slowly through the upper layer of spelter through the dross until the layer of lead is reached, then using the handle as a lever the shovel is slowly raised to the surface of the metal. This operation can be greatly facilitated with a single pulley block suspended from the overhead track used to remove the hood previously described. When the shovel and its contents have been drawn slowly clear of the metal, a slice bar should be forced through the dross and the handle of the shovel struck

several smart blows with a hammer to allow the spelter entrained with the dross to run back into the kettle.

The dross is placed in molds, about 15 in. x 9 in. x 4½ in., ready for market. The dross shovel is manipulated to the molds which are placed on the floor, by means of a block. The molds are filled with dross and smoothed off with an ordinary shovel while the metal is still hot. Dross sets very rapidly so that after a few minutes the molds may be emptied and refilled.

Frequent Drossing Necessary.

Drossing must be performed as often as necessary. When an excess of dross accumulates in the kettle it will show on the work. Once a week is sufficient in most cases when the kettle is being constantly operated, providing it has not been allowed to become over-heated. Over-heating may occur when the kettle is not in operation, and dross thus formed must be carefully guarded against. Before starting work after a shut down, the bath should be sounded to test the height of the dross. This is easily determined by the resistance encountered when an iron rod about ½ inch diameter is run into the bath. When replacing the spelter after drossing, it is necessary to see that the make-up metal is not fed too fast, as it may freeze the bath and set up very undesirable strains in the structure of the kettle.

Sweating Dross.

The advisability of sweating dross is largely a matter of locality and price. Formerly, every galvanizer "ran over" his dross for at that time the very best grade of dross would bring only 25 to 35 per cent of the price of virgin spelter, while today the most inferior grades bring 50 to 60 per cent and some of the better grades as high as 80 per cent of the price of virgin metal. As it is possible that a galvanizing plant may be so located that a ready market is not available for the wastes, it may be well to give directions for sweating dross.

A plan view and cross section through the center of the hearth of a sweating furnace is shown in F.g. 2. This furnace consists essentially of two arches of different radii, with the fire box and ash pit arranged in the center, the latter being sunk into the ground. The fuel may be natural gas, soft coal, fuel oil or gas-house coke, of these gas-house coke is to be preferred. The arch of the hearth proper, upon which the slabs of dross are placed, has a comparative short radius and terminates in two cast iron channel runways. The channels have a slope of 1 inch in 12 inches and pass through the doors to the front of the furnace where they terminate in a bowl, from which the reclaimed spelter is ladled into molds.

Care must be exercised in placing the slabs so that the products of combustion have free and easy circulation around them. As will be seen from the sectional view, the fire impinges directly upon the under side of the hearth, the waste gases passing through flues in the side walls to the top of the hearth, and then escape to the stack through suitable openings, low on the back wall.

Close fitting cast iron doors, with a renewable baffle plate on the inside and a good lap at the halves cover the entire opening in front of the hearth. The fire door is much smaller and need not be so carefully fitted, while the ash pit is usually left open. A self-supporting sheet iron stack about 18 inch diameter and 30 foot high will generally be found sufficient. The stack should be provided with a bonnet damper,

operated from the ground, to closely regulate the temperature on the hearth.

When the furnace is first put into operation, the spelter will have a tendency to set in the bowls, but this condition will disappear when the heat from the runways and hot spelter has had time to pass into the bowls. It is well to cover the spelter in the bowls with sal ammoniac flux to prevent oxidation. The spelter should be poured into molds of slightly different size from the standard spelter slabs, to differentiate between remelted and virgin spelter. Good work cannot be produced if too large a proportion of remelted spelter is used. It must be remembered that it is necessary to maintain a slow even heat which must at no time exceed 850 to 900 deg. F. on the hearth, as a temperature higher would burn the reclaimed spelter and defeat the desired object.

It may be taken for granted that to sweat dross does not pay at the present time, but there may be changes in the situation, and if such occurs the information and directions given for sweating dross will be found of value.

Improved Welding Methods Discussed

(Continued from page 514)

results indicate quite clearly that welds can be made by it which cannot be made by any other known means. However, the apparatus is hardly out of the laboratory stage and requires further development to fill general commercial conditions. It will be several months before the commercial apparatus will be ready for use.

Pictures illustrating the lecture given by Mr. Weinman and Mr. Alexander showed examples of the atomic hydrogen flame welding with an arc of 25 amperes; pure aluminum deposit on a cold rolled steel slab; a 25 per cent chromium steel, called Ascoloy No. 1; copper welded to Ascoloy No. 1; copper on cold rolled steel; copper welded to invar, a steel containing 35 per cent nickel and a weld made on alcumite.

On Friday morning, the directors of the society met in Hotel Statler and discussed details of the meeting of the society to be held next spring at Cleveland, when new officers of the association will be elected.

Following luncheon, the delegates boarded special buses bound for Niagara Falls, where they inspected the plant of the Niagara Falls Power Company. In the evening, they viewed a special illumination of the falls and afterwards assembled for dinner at the Niagara Hotel. Late in the evening, they returned to Buffalo.

Mr. Farmer, the president of the society, in the afternoon, had a luncheon conference with all the vice presidents and the section representatives, at the Buffalo Athletic Club.

About four o'clock in the afternoon, workmen began dismantling the exposition and the sixth fall meeting and the first international welding and cutting exposition drew to a quick close.

It was agreed upon at the termination of the convention when the writer talked to various exhibitors and convention delegates that the future of the industry never appeared brighter in its history than it does today. The rapid progress made by the laboratories of the individual firms were brought up as a convincing proof that the industry stood in a secure place.

Research Work at Bureau of Standards

(Continued from page 420)

without bringing the tensile strength outside the American Society for Testing Materials specification limits, and only the two latter, when 2 per cent is approached, cut the elongation below the limit.

The accelerated electrolytic corrosion test method for non-ferrous alloys cannot be recommended as a useful laboratory test in the form tentatively suggested by the American Society for Testing Material committee. There seems, however, to be much promise in the use of an electrolytic method when it is properly worked out and applied, if for no other purpose than to show qualitatively under what conditions protective coatings are formed.

Metal-to-metal wear, as when lubrication fails, upon railroad bearing metals is greater in the case of chill castings than in sand castings. The apparent or alleged advantage of chill castings for some types of service must be due to other properties than resistance to wear, especially to the properties at high temperatures, which will be studied.

While the picture of the metallurgical research at the Bureau of Standards given by this article is

incomplete, its purpose will be served if it brings the Bureau into closer contact with those in metallurgical industry who can use the facts brought out by such research and who will advise the Bureau as to how they think it can render still more or better service to the metallurgical industries and to the science of metallurgy.

Will Build Coke Ovens

Two batteries of by-product coke ovens will be built at the South Chicago works of the Youngstown Sheet & Tube Company next spring, according to James A. Campbell, president. Each battery will include 60 ovens of the Koppers type. The coal will be delivered by boat and unloaded into hoppers at the crushing plant. Contracts for filling in 15 acres of land along the shore have been awarded.

Coal Fields of the United States

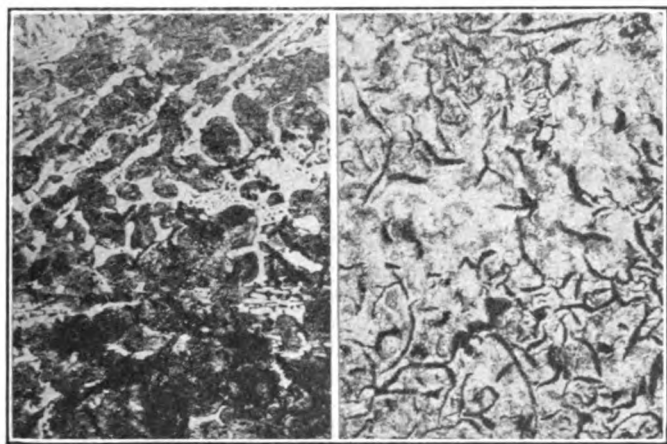
In making up the November issue of The Blast Furnace and Steel Plant part of the table giving analyses of representative coals of the United States was omitted. The balance of the table is printed below.

ANALYSES OF REPRESENTATIVE COALS OF THE UNITED STATES—Continued

State and Field or District	Kind of Coal	Moisture	Volatile	Carbon	Ash	Sulphur	Btu.
Utah—							
Carbon County	Bituminous	5.6	38.9	46.5	9.0	.5	12,150
Summit County	Sub-bituminous	14.2	36.0	44.8	5.0	1.4	10,650
Kane County	Semi-bituminous	9.5	13.2	49.2	28.1	3.6	8,850
Iron County	Bituminous	10.4	36.3	43.7	9.6	5.8	10,850
Virginia—							
Richmond	Bituminous	2.8	25.7	62.5	9.0	1.4	13,500
Pocahontas	Semi-bituminous	1.6	12.3	68.1	18.0	.5	12,350
Brushy Mountain	Semi-bituminous	3.8	15.5	77.8	2.9	.6	14,850
Russell Fork	Bituminous	2.5	31.7	60.3	5.5	.5	14,250
Black Mountain	Bituminous	3.4	34.4	58.8	3.4	.6	14,130
Washington—							
North Puget Sound	Bituminous	.3	22.3	62.4	14.9	.2	
North Puget Sound	Anthracite	4.4	7.4	76.0	12.2	1.0	12,600
South Puget Sound	Bituminous	7.4	37.4	43.9	11.3	.5	11,500
South Puget Sound	Sub-bituminous	15.9	36.0	38.5	9.6	.5	9,950
Roslyn	Bituminous	4.7	36.0	46.8	12.5	.4	12,250
Lewis and Colwitz	Bituminous	8.6	32.6	34.4	24.5	.9	9,250
West Virginia—							
Elk Garden	Semi-bituminous	1.1	17.2	73.8	7.9	1.1	14,250
Upper Potomac	Semi-bituminous	1.2	20.4	70.8	7.6	1.0	14,500
Roaring Creek	Bituminous	2.5	32.5	56.3	8.7	1.7	13,600
Panhandle	Bituminous	4.7	36.4	51.1	7.7	2.8	
Fairmont	Bituminous	2.9	34.5	56.9	5.7	1.5	14,000
New River	Semi-bituminous	1.3	16.3	77.1	5.3	.7	14,750
Kanawha	Bituminous	1.4	38.3	55.5	4.8	.9	14,300
Pocahontas	Semi-bituminous	1.7	17.8	73.6	6.9	.7	14,550
Tug River	Semi-bituminous	.6	19.4	75.1	4.9	.8	
Thacker	Bituminous	4.0	35.1	55.0	5.7	1.6	13,700
Kenova	Bituminous	1.7	36.8	55.5	6.0	.9	14,300
Wyoming—							
Sheridan	Sub-bituminous	22.6	32.5	40.4	4.5	.3	9,200
Cambria	Bituminous	8.9	36.5	33.8	20.8	4.0	10,000
Bighorn	Sub-bituminous	16.5	32.9	45.8	4.8	.6	10,750
Wind River	Sub-bituminous	14.8	34.0	42.6	8.6	.9	10,200
Hanna	Sub-bituminous	11.5	42.6	39.3	6.6	.4	10,900
Rock Springs	Bituminous	9.8	34.3	52.5	3.4	1.0	12,250
Kemmerer	Bituminous	5.7	37.7	51.3	5.3	1.4	12,600
Kemmerer	Sub-bituminous	20.6	36.3	40.5	2.6	.5	10,250
Evanston	Sub-bituminous	14.4	36.8	41.6	7.2	.2	10,450
Alaska—							
Alaska Peninsula	Bituminous	5.0	34.3	45.4	15.3	1.8	11,250
Alaska Peninsula	Lignite	23.3	35.4	25.1	26.2	.5	
Bearing River	Anthracite	5.9	6.8	81.5	5.8	.8	
Cook Inlet	Lignite	18.1	42.8	23.6	15.5	.4	7,900
Yukon River	Bituminous	2.1	20.8	54.0	23.1	.6	11,250

Alloy Cast Iron Produced in Electric Furnace

Statistics show that during the last decade the general use of grey iron castings has been steadily decreasing. Engineers have come to look upon cast iron as an inferior material. Malleable iron, forged steel, and steel stampings are used to a considerable extent for purposes where formerly cast iron was considered good enough and this humble product is being used more and more only where its mass is of value. Cast iron is at last however making a strong bid for its former place in industry in the shape of alloy cast iron.



(Left)—Photomicrograph of a wear resisting cast iron. (Right)—Photomicrograph of alloy cast iron for pistons and cylinders having fast machinability at Brinell 196.

In Western Pennsylvania at Latrobe, The Vulcan Mold & Iron Company has been experimenting for the past two years on alloy cast iron melted in an electric furnace and is now placing on the market products made of this material. The regular product of this company is ingot molds designed chiefly for manufacture of high grade soft steels, alloy steels, and tool steels which consist of both split molds and solid molds of the latest type. During some research work on various grades of cast iron to determine their suitability for ingot molds, alloy cast iron was made in a crucible, melted in a resistance type electric furnace.

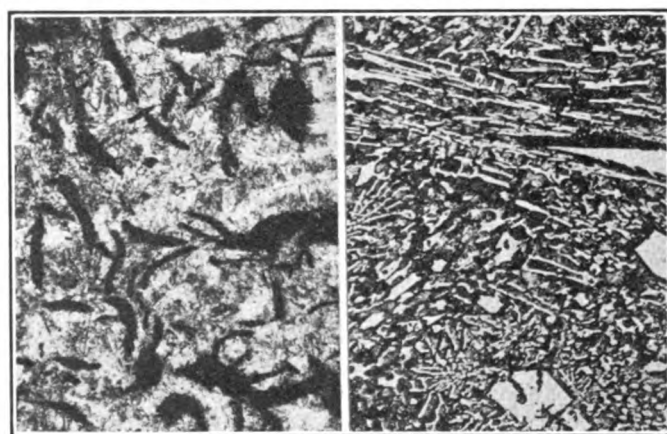
It did not take long to determine that there was a considerable field for this type of product and led to the leasing of a nearby foundry which had formerly been engaged in the manufacture of pipe fittings. The foundry was remodeled and a considerable amount of new equipment was added which included traveling crane and monorail systems, modern molding and core-making machinery, and other equipment designed for the production of these special castings from one pound to one ton in weight. The most important addition, of course, was the installation of a half ton Moore electric furnace, particularly designed for melting cast iron and having a complete automatic control system.

The electric furnace has a capacity of 10 tons of alloy cast iron and the cupola about 20 tons of grey iron castings per day. This plant now produces all of the split ingot molds which the company manufactures made of both cupola iron and alloy cast iron. The chief aim of this plant however is the development of electric furnace alloy cast iron and already a large number of castings have been placed on the market. These include die blocks, hammer dies, auto-

mobile parts such as pistons, cylinder blocks, special molds for the glass industry, heat resisting iron for furnaces and ovens, and wear resisting castings such as pipe balls and piercing points. In all cases where comparative results were obtained this alloy iron has proved itself superior to the ordinary cupola iron.

In the manufacture of this material, The Vulcan Mold & Iron Company have found it highly advisable to use an electric furnace. Practically a complete recovery of the alloys is made possible by this method due to the absence of oxidation and high temperatures. It was also found that an absolute control of composition could be made and that when the proper analysis for a given casting was found it could be readily duplicated. The very desirable condition of low sulphur content was also procured. Alloy iron of very low carbon content, almost on the border line between iron and steel, has been made with comparative ease. Melting takes place in the usual manner, the charge generally consisting of pig iron and steel scrap; the alloys being added just before tapping the heat.

A number of unusual properties have been produced in this iron by varying the amount of alloys together with changes in the percentages of the ordinary constituents of cast iron. In castings of very small sections it is possible to produce an iron having a very dense, close-grained structure, pearlite in character, which can be machined readily at a much higher Brinell hardness than is possible with ordinary grey iron. This is done by the elimination of hard spots, chilled corners, and by having the graphite more evenly distributed and in a finer divided state. Castings of large sections have been made with only a slight variation in hardness from outside to center and machinable at normal speeds with Brinell hardnesses of over 300. These castings are very strong, tough,



(Left)—Photomicrograph of alloy cast iron die block. This was machined with a Brinell of 302. (Right)—Photomicrograph of alloy heat resisting cast iron suitable for furnaces and ovens.

and resistant to wear. Where high strength is desirable, castings have been made with tensile strength on a standard A.S.T.M. test bar of over 40,000 lbs. per sq. in. and a transverse strength of 4,550 lbs.

Practical experiments on heat resisting alloy cast iron made with high percentages of alloys have shown a freedom from excessive oxidation at high temperatures. The experiment conducted under similar conditions of temperature and time on pieces of alloy iron and ordinary cupola iron showed a loss of 2 per cent on alloy iron and 30 per cent on cupola iron.

PERSONALS

Th. McGraw, Jr., was elected president of the Braeburn Alloy Steel Corporation, Braeburn, Pa., at the annual board of directors meeting, November 1. Mr. McGraw, for the past six months had been chairman of the board. He had served as secretary and a director of the Standard Seamless Tube Company, Ambridge, Pa., for 12 years, and for two years as general manager of the Carbon Steel Company, Pittsburgh.

* * *

A. F. MacFarland, recently appointed sales agent in Michigan by the Cyclops Steel Company, Titusville, Pa., formerly was a district sales manager for the Vanadium Alloys Steel Company, Latrobe, Pa.

* * *

John R. Stroh has been appointed western sales agent with offices at 302 First National Bank Building, Youngstown, for the Pittsburgh Metallurgical Company, Niagara Falls, N. Y., producers of ferro-silicon.

* * *

James A. Campbell, president, Youngstown Sheet & Tube Company, Youngstown; H. L. Rownd, vice president, Republic Iron & Steel Company, that city; A. E. Adams, Benjamin Ebans, George H. Gessner, Rev. M. F. Griffin and C. J. Strouss recently were elected directors of the Youngstown Chamber of Commerce.

* * *

James R. Mills, district manager in Cleveland for the Carnegie Steel Company, Pittsburgh, has been chosen a member of the board of education in Cleveland, to fill a vacancy.

* * *

E. J. Poole, general superintendent, has been advanced to vice president in charge of operations of the Vanadium Alloys Steel Corporation, Latrobe, Pa. He succeeds W. S. Jones, who resigned to join the Carpenter Steel Company.

* * *

Arthur C. Flory, manager of the steam turbine department of the Allis-Chalmers Mfg. Company, Milwaukee, has been elected president of the Engineers' Society of Milwaukee. New directors include Fraser Jeffrey, Allis-Chalmers Mfg. Company, and John D. Maurer, general manager of the Illinois Steel Company, Milwaukee works.

* * *

E. LeRoy Harrington, clamshell bucket engineer and designer, has joined the Blaw-Knox Company, Pittsburgh, manufacturer of steel products.

* * *

Edward J. Costello, Jr., has joined the Blaw-Knox Company, on its sale staff covering the Philadelphia territory. He will specialize on the sale of standard steel buildings.

* * *

Walter F. Brumm, recently appointed assistant district sales manager in the St. Louis office of the Inland Steel Company, Chicago, formerly held similar office at the Kansas City, Mo., branch. Prior to his affiliation with the Inland company he had been with Carbria Steel Company, Midvale Steel Company and Bethlehem Steel Company.

P. J. Moran, formerly in the Cleveland office of the Hanna Furnace Company now is located at Detroit as manager of the Detroit plant. J. R. Comstock, formerly of the Cleveland office, has been made manager of the Dover and Cherry Valley furnaces with headquarters at Dover, O. V. W. Aubel, has been transferred from Detroit to Buffalo, as assistant to B. Marron, manager there. W. T. Clarke, engineer, formerly of the Cleveland office, has been stationed at Detroit.

* * *

John C. Taylor, Jr., has been appointed general sales manager for all products of the Taylor-Wharton Iron & Steel Company, High Bridge, N. J. He formerly had charge of sales of manganese steel products. He now will have charge of sales for William Wharton, Jr. & Company, Easton, Pa., Philadelphia Roll & Machine Company, Philadelphia, and Tioga Steel & Iron Company, Philadelphia, as well as for the Taylor-Wharton company.

* * *

Charles A. Moffet, president of the Gulf States Steel Company, Birmingham, Ala., has resigned from that office to become chairman of the Alabama board of control and economy under Governor B. Groves. Mr. Moffet went with the Southern Iron & Steel Company in 1909 and later was with the Gulf States company as works manager at Alabama City. In 1916 he was vice president and general manager of all plants. In the reorganization of 1921 he became president.

* * *

Walter C. Rott, formerly with S. R. Smythe Company and Julian Kennedy, consulting engineers, has joined the furnace division of the Rust Engineering Company, Pittsburgh, effective November 15.

* * *

John F. Hazen, formerly general manager of sales of the Pittsburgh Steel Company, has joined the sales department of Bethlehem Steel Company, with headquarters in Bethlehem, Pa. He will specialize in wire products.

* * *

Gregory J. Comstock, formerly metallurgist of International Silver Company, Meriden, Conn., has been appointed director of research of the Firth-Sterling Steel Company, McKeesport, Pa. Mr. Comstock was graduated from the Sheffield scientific school of Yale University in 1917 with the degree of bachelor of philosophy, and served in the army from 1917 to 1919. After that he was assistant chemist for the American Hardware Corporation for a short time, becoming metallurgist of the International Silver Company in 1920.

* * *

Owen K. Parmiter has been appointed metallurgical and sales engineer of the Firth-Sterling Steel Company, McKeesport, Pa. After Mr. Parmiter's graduation from the University of Pittsburgh in 1910, he was alloy and tool steel chemist with the Firth-Sterling Steel Company for three years and then became assistant metallurgist. In 1918, he was appointed metallurgist in charge of all technical operations, which position he has held until his appointment as metallurgical and sales engineer.

* * *

Thomas W. Kennedy, general manager of the Mystic Iron Works, Boston, has been appointed president

to succeed Capt. William E. McKay, who becomes chairman of the board. Mr. Kennedy will continue in his capacity as general manager.

* * *

George C. Mills was appointed sales representative for the Vulcan Mould & Iron Company, Latrobe, Pa., effective November 15. Mr. Mills previously represented at Pittsburgh the Vom Baur Engineering Corporation, New York, in the sale of its electric melting furnaces, etc. Prior to that he was Pittsburgh agent for Naylor & Company, Inc., New York, whom he represented for 25 years.

* * *

G. W. Mead has been elected a vice president and a director of the Union Carbide & Carbon Corporation, and W. F. Barrett has been elected a vice president. Both are active figures in various subsidiaries of Union Carbide & Carbon Corporation, particularly the Linde Air Products Company, of which Mr. Mead is chairman of the board and Mr. Barrett, president. Mr. Mead also is vice president and a director of the Union Carbide Company.

* * *

Francis B. Foley, since 1924 metallurgist, Lucey Manufacturing Corporation, Chattanooga, Tenn., has been made superintendent of the research department of the Midvale Company, Nicetown, Philadelphia.

* * *

E. H. Schwab, brother of Charles M. Schwab, has been elected president of the Splittorf Electrical Company, Newark, N. J., to succeed M. W. Bartlett, who is retiring. Mr. Schwab has been chairman of the board since 1924, when the Splittorf interests were merged with the Bethlehem Spark Plug Company.

* * *

John A. Oartel, safety director Carnegie Steel Company, Pittsburgh, recently was re-elected president of the Safety Council of Western Pennsylvania.

* * *

Burton L. Delack, assistant manager of the Erie, Pa., works, General Electric Company, has been appointed assistant manager of the Schenectady, N. Y., works, effective December 1. At the same time John St. Lawrence, general superintendent at Erie, has been named to succeed Mr. Delack there.

OBITUARIES

Elton B. Hull, in charge of blast furnace and coke operations of Pickands, Mather & Company, Cleveland, died at his home in Cleveland Heights, November 22. He was born January 10, 1872 near Sharon, Pa.

* * *

Thomas H. Mirkil, Jr., Philadelphia district sales manager for the Treadwell Engineering Company, Easton, Pa., builder of rolling and other machinery and maker of castings, died November 12.

* * *

James Guthrie Caldwell, former president of the Birmingham Rolling Mill Company, with works at Birmingham, Ala., died November 16 at his home in Louisville, Ky., aged 71 years.

G. A. Sacchi, manager of the stoker sales department, Westinghouse Electric & Mfg. Company, died suddenly November 4, at his residence in Lansdowne, Pa.

* * *

William Larimer Jones, president of the Jones & Laughlin Steel Corporation, Pittsburgh, died November 25, in that city, aged 61, after a brief illness of pneumonia. Honorary pallbearers at his funeral were William Albright, Frank S. Slocum, T. M. Girdler, Milton C. Angloch, Richard Mahla, W. C. Moreland, A. B. Shepherd, George M. Laughlin, Jr., J. B. Laughlin, F. B. Hufnagle, M. J. Dowling, W. S. Arbuthnot, Frank McCune, J. H. Lockhart, Stewart Johnston, Samuel R. Kelly, George A. Kelly, Father Devlin, R. B. Mellon, William M. Hall and John Jamison.



WILLIAM L. JONES

Mr. Jones was born in Chicago, December 7, 1865 and was graduated from Princeton university in 1887 with the degree of bachelor of science. After graduation he came to Pittsburgh as assistant to his father, the late Thomas M. Jones, who was general manager of the Jones & Laughlin works. Upon the death of his father in 1889 he succeeded him in the general managership. In 1906 he was elected vice president of the company and was made president of the corporation at the time of its formation in December 1922. He was also president and director of the Jones & Laughlin Steel Corporation's subsidiary companies including the Blair Limestone Company and the Vesta Coal Company. He held directorships in many industrial and financial institutions, including the Graham Nut & Bolt Company, the Mellon National Bank, and the South Side Hospital.

Mr. Jones was a member of the American Iron and Steel Institute, the American Institute of Mining and Metallurgical Engineers, and the Engineers' Society of Western Pennsylvania, and belonged to the following clubs: The University and Princeton, New York; the Nassau and the Ivy at Princeton, and the following Pittsburgh clubs: The Pittsburgh, Duquesne, Country, the Allegheny, the Fox Chapel, the Pittsburgh Golf, the University, and the Pittsburgh Athletic Association.

* * *

Thomas M. Adams, 72 years old, a pioneer in the iron and steel producing industry in the Ohio Valley, died November 15 at Ashland, Ky., from injuries received November 13 when struck by an automobile.

* * *

Patrick William O'Brien, aged 66 years, in charge of the rail bureau as assistant general manager of sales for the Illinois Steel Company, Chicago, died November 9 after a week's illness of influenza and pneumonia.

* * *

Donald Fairfax Bush, long a leading figure in the pig iron and ferro-manganese trades in the United States, and identified with numerous other activities, died November 26, at his home in New York, of angina pectoris.

TRADE NOTES

Bethlehem Steel Company has started an addition to its structural steel fabricating plant on Abby Street, Buffalo, N. Y. The new structure will be 90 x 500 feet and will provide considerable enlargement in production facilities.

* * *

Hydraulic Press Manufacturing Company, Mt. Gilead, Ohio, whose head offices have been in that city for 50 years, has moved its sales and engineering departments to the City National Bank Building, 20 East Broad Street, Columbus, Ohio. Paul C. Pocock will be in charge.

* * *

Wheeling Steel Corporation has moved its Boston office from 120 Franklin Street to the Statler Building.

* * *

Link-Belt Company, Chicago, manufacturer of chain for industrial uses, has opened a sales and service branch at 152 Temple Street, New Haven, Conn., in charge of R. H. Hagner, formerly in the company's Philadelphia office.

* * *

In connection with additions to its Sparrows Point, Baltimore plant, soon to be placed under way, the Bethlehem Shipbuilding Corporation is planning for the removal of the ship construction and ship repair departments from its Harlan works, Wilmington, Del., to this location. The company recently acquired about 12 additional acres near its Key Highway, Sparrows Point yard for expansion. It is understood that the Harlan plant will be used exclusively for car building and repair work in the future. The extension program at Sparrows Point is estimated to cost in excess of \$1,000,000.

* * *

Property at Berkeley, Cal., has been acquired by the B. F. Sturtevant Company, Hyde Park, Boston, manufacturer of mechanical draft equipment, turbo-blowers, etc., as a site for a proposed branch plant, to cost about \$100,000 with equipment.

* * *

Frank W. Hamilton, with several New York business men has purchased the interests of Cadwallader R. Mulligan in the Ulster Iron Works, Dover, N. J., which has manufactured puddled wrought iron bars for a century.

* * *

Progress on a five-story arc-welded building at Sharon, Pa., being erected by the Westinghouse Electric & Mfg. Company, has advanced until it is possible to make a load test. A public test will take place December 15 and 16, when a portion of the third floor will be loaded to twice the load for which the floor is designed. It is planned to place 840,000 pounds on an area of 1,400 square feet.

* * *

An ingot mold plant, involving an expenditure of \$750,000, will be built by the Valley Mould & Iron Corporation, Sharpsville, Pa., on a 15-acre site adjoining the Hubbard stacks of the Youngstown Sheet & Tube Company, Hubbard, O. The latter company will increase its boiler capacity and make improvements to the stacks at a cost approximating \$500,000.

Book Review

Arc Welding, the New Age in Iron and Steel. Prepared and published by The Lincoln Electric Company, Cleveland, Ohio, 160 pages, 6 x 9 inches, illustrated. Price \$1.50.

This book is devoted largely to the use of arc welding in general production manufacturing. No longer can arc welding be looked upon as a repairing or salvaging process. The arc welder is a production tool and this book makes it very evident that a knowledge of arc welding principles must be a part of the equipment of every designer and manufacturer working in iron and steel. The book contains more than 200 illustrations, chiefly of products of representative manufacturers which have been manufactured by arc welding. In addition there are numerous diagrams and charts showing welding speeds and costs.

The book points out that there are two main fields for production welding. The first and perhaps the best known is the use of arc welding in place of riveting. It is demonstrated in this book that a welded joint can be 100 per cent efficient whereas the strength of a single riveted joint can never equal the strength of the members joined. Tank builders were among the first to recognize the greater economy of arc welding over riveting and today there is probably not a tank shop of any importance that does not use arc welding. Many other products formerly riveted, but now arc welded are illustrated and described.

The second main field for arc welding is the substitution of arc welded steel for cast iron. This book makes the claim that 90 per cent of the iron castings now used could be replaced by arc welded steel at a decided saving. There is a complete discussion of how to go about redesigning cast iron for manufacture in steel and the illustrations show clearly where this is being done commercially by representative manufacturers. The fundamental reason of the economy of arc welded steel over cast iron is that steel is six times as strong as cast iron in tension, two and a half times as stiff, but costs only one-third as much. Examples of complicated machinery bases and other cast iron parts are shown reproduced in welded steel and in many instances cost figures are given.

The opening chapter of this treatise discusses the superiority of steel over cast iron from both the standpoints of strength and economy. The addenda to Chapter I is a technical discussion of this subject with diagrams and references of recognized authorities.

Probably the most impressive point about the book is the wealth of illustrations showing products which are now being manufactured by means of this new process. The procedure for redesigning machine parts is treated at length and there is complete data on the strength and cost of various types of welded construction. One chapter is devoted to automatic arc welding and there are numerous photographs of products automatically welded.

New annealing furnaces and shears will be installed at the Western Reserve Division of the Youngstown Sheet & Tube Company, Warren, Ohio, at an expenditure of \$220,000. The output of the hot mills at this plant will be devoted exclusively to blue annealed sheets.

TRADE PUBLICATIONS

Tramrails—Handling materials by means of its tramrail systems is shown in pictorial form in a folder published by the Cleveland Crane & Engineering Company, Wickliffe, O.

* * *

Draft Gauges—Foxboro Company, Inc., Foxboro, Mass., has issued a bulletin on its draft gauges to indicate the presence of excess air in steam plants, showing where it is present, that its presence may be remedied.

* * *

Centrifugal Pumps—Single-stage, double-suction, volute centrifugal pumps of several different sizes are described in a catalog issued by the Ingersoll-Rand Company, New York. Cross sections of the various parts are shown to give constructional features.

* * *

Vibrating Screens—A ball-bearing vibrating screen recently perfected by the Link-Belt Company, Chicago, is described and illustrated in a bulletin showing the essential parts and their construction.

* * *

Electric Furnaces—A catalog by William Swindell & Brothers, Pittsburgh, covers its line of furnaces, illustrated by installations of melting and heat-treating furnaces. Accessories are also illustrated.

* * *

Open Steel Flooring—A card containing a chart of load curves and deflections in the grill type of open flooring has been issued by the Irving Iron Works Company, Long Island City, N. Y. This is a guide to the application of this material for various spans and loads.

* * *

Boiler Feed Pumps—Its centrifugal boiler feed pumps are described and illustrated in a bulletin by the Pennsylvania Pump & Compressor Company, Easton, Pa. A large cross-section shows details of construction and standard construction is described.

* * *

Roller Bearings—Timken Roller Bearing Company, Canton, O., has issued its engineering data relating to bearings in loose-leaf form with a binder. It includes load calculations, bearing selection, ratings and dimensions, mounting, adjustment, closures, assembly methods, lubrication and shop inspection.

* * *

Motors—Totally enclosed, fan-cooled d.c. motors are described and illustrated in a bulletin by the General Electric Company, Schenectady, N. Y.

* * *

Industrial Electric Heating—StaWarm Electric Heater Corporation, Ravenna, O., has issued a bulletin covering its industrial heating devices for various uses.

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Iron Economy—American Rolling Mill Company, Middletown, O., has issued a booklet calling attention to the need for economy in iron and suggesting the use of metal which resists corrosion as one means to this end. It is well illustrated to show installations which resist unusual corrosive influences.

Refractory Cement—A bulletin describing the experience of a steelmaker in using its refractory cement in laying fire brick, has been issued by the Botfield Refractories Company, Philadelphia.

* * *

Carbon Monoxide Meter—Bacharach Industrial Instrument Company, Pittsburgh, has issued a leaflet on its electric meter for measuring carbon monoxide in the adjustment of high speed internal combustion engines.

* * *

Steel Windows—Mechanisms for opening and closing steel windows in industrial buildings are described in a catalog issued by the Truscon Steel Company, Youngstown, O. These devices are for hand or motor operation and simplify greatly the control of large continuous window areas.

* * *

Arc Welding—Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., has issued a 31-page publication devoted to welding of structural steel. It deals with arc welded buildings at the East Pittsburgh works of this company, erection methods, tests and inspection of arc welds and the metallurgy of welding. It includes discussion of tests of actual joints and the results of tests by the Carnegie Institute of Technology.

* * *

Engine Lubrication Instruction—Climax Engineering Company, Clinton, Iowa. Booklet dealing with the proper lubrication of heavy-duty, medium-speed industrial engines. Full particulars for oiling are given with illustrations and diagrams. Points stressed are the use of oil of a high quality and the correct grade to meet operating conditions, as well as the correct use of this oil to insure delivery to bearing surfaces in proper amounts at all times.

* * *

Ball Bearings—New Departure Mfg. Company, Bristol, Conn. "Cutting Your Costs," a brief bulletin devoted to a discussion of the cost and comparative advantages of equipping electric motors with ball bearings. Considerable data, based upon actual demonstrations, are offered.

* * *

Refractories—Stowe-Fuller Company, Cleveland, has issued a pocket-size catalog of its refractory brick, fully illustrated and containing complete data for the user.

* * *

Roll Lathes—Mesta Machine Company, Pittsburgh, is distributing a catalog covering its lathes for turning rolls, showing details and giving data for selection of the proper lathe for various classes of work. It is thoroughly illustrated.

* * *

Flow Meters—A new type of steam flow meter is described in a bulletin by the Brown Instrument Company, Philadelphia. The new principle on which the meter operates to show the passage of steam is fully illustrated.

* * *

Pyrometer Controllers—Bristol Company, Waterbury, Conn., has issued a bulletin covering automatic temperature control in heat treatment of steel by means of its devices.

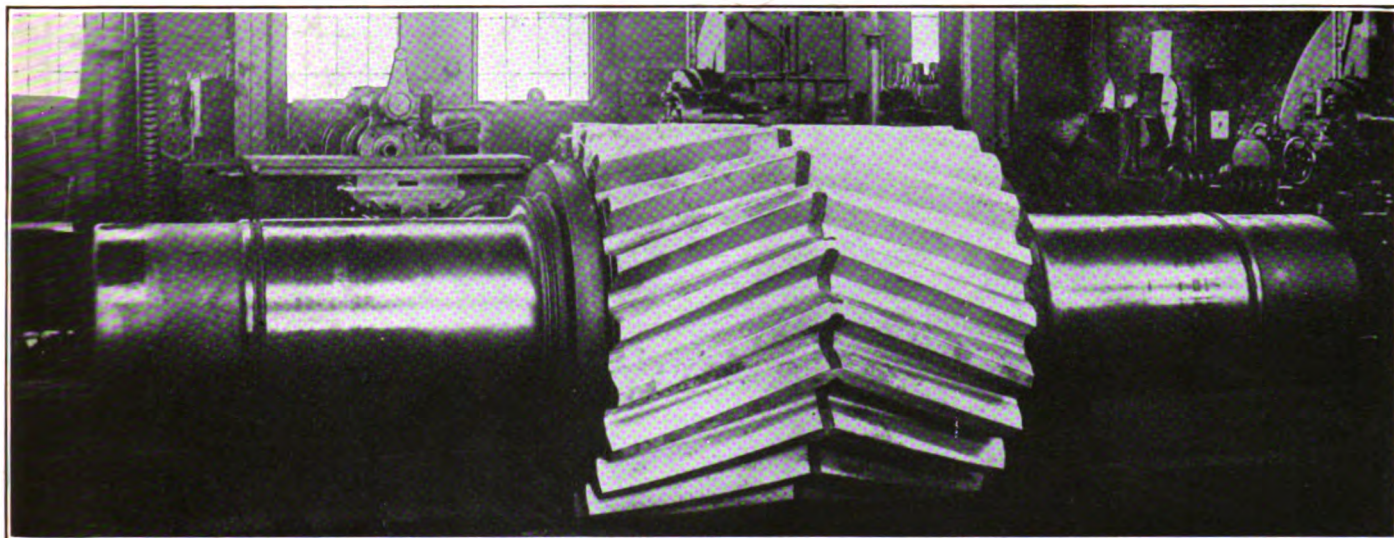
The Blast Furnace *(and)* Steel Plant

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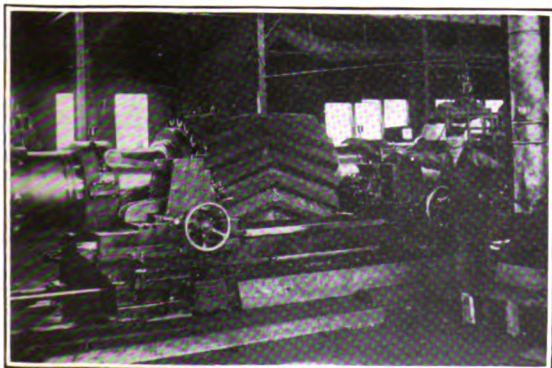
Fawcus Herringbone Mill Pinions



Largest Mill Pinion Ever Made—20 teeth, 8.4823" C.P., 54" P.D., 60" Face, Weight 75,000 lbs.

This shows one of four FAWCUS HERRINGBONE MILL PINIONS furnished for one of the largest steel mills in America. The teeth are of special design in order to insure the maximum bearing surface and rolling contact.

Whatever your requirements, our experience and our facilities are such that we can meet them—either to your dimensions and instructions, or to our design and recommendations. In either case our product will bear a strict guarantee of satisfactory material and workmanship.



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NEW ORLEANS	- - - - -	Southern Engineering & Supply Co.
BOSTON	- - - - -	15 Exchange St.
MONTREAL, CANADA	- - - - -	Hicks & Newill, 189 St. James St.